



DRA

Project Manual – Volume 2 of 2

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Northeast Metropolitan Regional Vocational High School

Wakefield, Massachusetts

MSBA 90% CD SUBMISSION

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ARCHITECT

DRUMMEY ROSANE ANDERSON, INC.

260 Charles Street, Studio 300

Waltham, MA 02453

PROJECT MANUAL

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By CM/OPM

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GENERAL REQUIREMENTS FOR FIRE PROTECTION

PART 1 - GENERAL

1.0 FILING OF TRADE BIDS

- A. Trade bids shall be submitted in accordance with the provisions of Massachusetts General Laws (Ter. Ed.), Chapter 149, SECTION 44A TO 44L, inclusive, as amended. The time and place for submission of trade bids shall be as set forth under INSTRUCTIONS TO BIDDERS.
- B. Each trade bid filed with the Awarding Authority shall be accompanied by a BID BOND, CASH or CERTIFIED CHECK, or a TREASURER'S CHECK or CASHIER'S CHECK issued by a responsible bank or trust company, payable to the Town of Wakefield, the amount stipulated in the INSTRUCTIONS TO BIDDERS. A trade bid accompanied by any other form of bid deposit than those specified will be rejected.
- C. Each trade bid submitted for the work under the Section, shall be on a form furnished by the Awarding Authority, reference SECTION 44F of Chapter 149 of the General Laws, as amended.
- D. Work to be done under this Section is shown on the Drawings: FP0-0-1, FP1-1-0.5CD, FP1-1-0C, FP1-1-0D, FP1-1-1.5AB, FP1-1-1A, FP1-1-1B, FP1-1-1C, FP1-1-1D, FP1-1-2A, FP1-1-2B, FP1-1-2C, FP1-1-2D, FP1-1-3A, FP1-1-3B, FP1-1-3C, FP1-1-3D, FP1-1-4A, FP1-1-4B, FP1-1-4C, FP1-1-4D, FP1-2-1A, FP1-2-1B, FP1-2-1C, FP1-2-1D, FP5-0-1, FP6-0-1.
- E. The listing of the Contract Drawings above shall not limit responsibility to determine the full extent of work of this Section as required by all Contract Drawings noted on the Contract Drawings-Title Sheet Drawing List, the Project Manual, and Addenda.
- F. Refer and comply with General Instructions prepared by the CM-R.
- G. Work to be done under this SECTION 210000 shall refer to and include the following specification SECTIONS:

21 00 00	GENERAL REQUIREMENTS FOR FIRE PROTECTION
21 00 05	COORDINATION DWG REQ FIRE PROTECTION
21 05 17	SLEEVES AD SLEEVE SEALS FOR FIRE SUPPRESSION PIPING
21 13 13	FIRE PROTECTION PIPING SYSTEMS
21 29 33	CONTROLLERS FOR FIRE PUMP DRIVERS
21 31 13	FIRE PROTECTION PUMP SYSTEMS

- H. The filed Trade Bidder for Work under this SECTION 210000 shall list in Paragraph E of the FORM FOR TRADE BID the names of each person or corporation whom he proposes to use to perform the following classes of work or part thereof and the bid price, therefore.

CLASS(ES) OF WORK

REFERENCE ARTICLE(S)

Site supply water system

- I. In any case in which the sub-bidder intends to perform with persons of their own staff the class of work listed above, they must nevertheless list their own name therefore under Paragraph E of the FORM FOR SUB-BID.

GENERAL REQUIREMENTS FOR FIRE PROTECTION

- J. The Fire Protection Subcontractor and associated Sub-Subcontractors are specifically directed to review the Fire Protection Narrative Report. All design criteria, coordination issues, testing, and other related items, must be incorporated prior to acceptance of the Fire Protection Systems.

1.1 GENERAL REQUIREMENTS

- A. Examine all other Sections of the Specifications for requirements which affect work under this Section whether or not such work is specifically mentioned in this Section.
- B. Refer to the Drawings for further definition of location, extent, and details of the work described herein.
- C. Cooperate and coordinate with all trades in execution of the work described in this Section and so as to provide clearance for equipment maintenance and operation.
- D. Where referred to, Standard Specifications or Technical Societies, Manufacturer's Associations, and Federal Agencies shall include all amendments current as of the date of issue of these Specifications.
- E. It is intended that the Manufacturer's name used first throughout this Section of the Specification, is that used in the design of the system. All material submitted shall be equal in all respects to that used in the design.
- F. Performance Criteria:
1. The Fire Protection Engineer has developed the performance and design criteria for the fire protection systems. The Fire Protection work shall be done on the basis of a "shared design" responsibility, in accordance with the State approved Method 'B' option for providing fire protection work in Massachusetts. The Fire Protection Subcontractor is responsible for engaging a qualified Registered Fire Protection Engineer (FPE) or NICET Level IV layout technician (Designer), certified in automatic sprinkler system layout to prepare the "Installation" drawings, and hydraulic calculations.
 2. The "Installation" Drawings shall be prepared in accordance with the requirements of the latest editions of NFPA-13, 14, 20 and 24 along with the requirements indicated in the Contract Documents. It is the responsibility of this Subcontractor to fully coordinate all aspects of the system layout with the building construction features and all installing trades, and to confirm the preliminary design and design criteria.
 3. The final system "Installation" Drawings and all supporting information including hydraulic calculations, material and equipment submittals, shall be submitted through the Architect for review and approval prior to fabrication and installation.
 4. The submittal review process may require system modifications or alterations, additional or revised hydraulic calculations, material changes, if in the opinion or interpretation of the Fire Protection Engineer, the intent of the design criteria or standards are not being met.
 5. Following approval of the submittal by the specifying Fire Protection Engineer, the Fire Protection Subcontractor may proceed with submittal to appropriate authorities as indicated in the Specifications and may apply for the permit to install.; upon which time fabrication and installation are then authorized, in accordance with the Project Schedule
 6. The Fire Protection Subcontractor is required to maintain current: (1) Sprinkler Contractor's license and, (2) Errors and Omissions Insurance.
- G. Where an item is referred to in singular number in Contract Documents, provide as many such items as are necessary to complete work.
- H. Before starting work of this Section, visit site and examine conditions under which work must be performed including preparatory work done under other Sections or Contracts or by Owner.

Report conditions that might affect work adversely in writing through the General Contractor to Architect. Do not proceed with work until defects have been corrected and conditions are satisfactory. Commencement of work shall constitute complete acceptance of existing conditions and preparatory work.

- I. All work shall be performed in accordance with the State Building Code, NFPA, the Local Fire Prevention Department, the Insurance Underwriter and all Local Codes and Ordinances.
- J. The Fire Protection Subcontractor shall work out the "means and methods" of performing the work with the General Contractor.
- K. Refer to the Alternates Section 012300 for all Alternates which may affect the work of this Section.
- L. The Fire Protection Subcontractor is specifically directed to review the Fire Protection Narrative Report. All design criteria, coordination issues, and testing shall be incorporated prior to acceptance of the Fire Protection Systems. Refer to Part 4 of this Specification Section for the Narrative.
- M. Control Compliance:
 - 1. All computer equipment hardware and software provided under this Section which has microprocessor based control or monitoring functions which utilize date information shall operate without any error of any nature relating to date data, and without limiting the generality of the foregoing, such hardware, software and systems will not terminate ordinary operations nor produce invalid or incorrect data or information as a result of the input of date data.
 - 2. Any problems arising because of non-compliance with the above shall be corrected by the Contractor without cost to the Owner.

1.2 SCOPE OF WORK:

- A. These specifications and accompanying drawings are intended to cover the furnishing of all labor, material, and equipment and superintendence of the Fire Protection System for this project. They are also intended to cover performing all miscellaneous operations including excavations and backfilling, cutting, channeling, chasing, and patching necessary for the installation of the Fire Protection systems, as shown on the drawings, as hereinafter specified, as directed by the Engineer or as may be required for a complete and fully functional Fire Protection installation.
- B. The entire dedicated fire protection water supply, on site, shall be furnished and installed as a part of the SECTION 210000 work into the building and including all work within the building. The design of the work in the building to 10 feet outside the building wall is shown on the "FP" Drawings and as indicated herein. The design of the work starting at the beginning of the dedicated fire protection water supply, to 10 feet from the building, including all piping, fittings, hydrants and miscellaneous appurtenances, is shown on the documents indicated in Paragraph 1.0.
- C. It is the intent and purpose of these specifications and accompanying drawings to cover and include each item, all materials, machinery, apparatus, and labor necessary to properly install, equip, adjust, and put into perfect operation the respective portions of the installations specified and to so interconnect the various items or sections of the work as to form a complete and properly operating whole.
- D. Drawings and specifications have been prepared with best knowledge of conditions available at the time of design and are intended to be complementary. What is called for by one shall be as

binding as if called for by both. Where conflicts occur between drawings and specifications, or between the Fire Protection documents and the documents of other disciplines, the situation shall be brought to the attention of the Design Professional before the work in question is installed. In case of conflict between provisions of the Specifications or between the drawings and the specifications, the more stringent requirement shall govern. Where a requirement is applied to a specific product, condition, system, or Specification Section which conflicts with a more general requirement elsewhere, the specific shall supersede the general. If any obscurities or discrepancies exist, they shall be brought to the attention of the Design Professional before bids are submitted. If they are not discovered before bids are submitted, the Design Professional shall be notified and shall render a decision. This decision shall be final.

- E. Any equipment, apparatus, machinery, material, and small items not mentioned in detail, and labor not hereinafter specifically mentioned, which may be found necessary to complete or perfect any portion of installation in a substantial manner, and in compliance with the requirements stated, implied, or intended in these specifications shall be furnished without extra cost. This shall include all materials, devices, or methods peculiar to the machinery, equipment, apparatus, or systems furnished and installed as part of the Fire Protection work and shall include major components if so required.
- F. The general arrangement of piping, and equipment shall be as identified on the contract drawings. Carefully examine all contract drawings and be responsible for the proper fitting of materials and equipment in each location as indicated. Inasmuch as the drawings are generally diagrammatic, due to their small scale, it is not possible to indicate all offsets, fittings, and accessories, as may be required in the final installation. Carefully investigate the site, structural, and finish conditions affecting their work and arrange such work, accordingly, providing such fittings and accessories as may be required to meet such conditions, at no additional cost to the Owner. The right to make any reasonable change in location of apparatus, equipment, outlets, or routing of piping, up to the time of roughing-in, is reserved by the Design Professional without involving any additional expense to the Owner.
- G. Should a bidder find discrepancies in or omissions from the drawings or specifications they shall notify the Design Professional before submitting their bid proposal. The Design Professional shall then send written instructions, via Addendum, to all known bidders. Oral instructions shall not be binding to either the Design Professional or the Owner.
- H. In the case of discrepancies or conflicts between the Drawings and Specifications, typically the Drawings will take precedence in the case of quantitative issues, while the Specifications will take precedence for qualitative issues; or as specified in other Divisions; however, when the scale and date of the Drawings are the same, or when a discrepancy exists within the Documents and specific written direction cannot be obtained from the Design Professional, Bidders shall include the most stringent requirements. Obtain written clarification from the Engineer prior to installation.
- I. Any such items not brought to the attention of the Design Professional prior to submission of the bids shall be subject to the interpretation of the Design Professional. All such interpretations shall be accepted by the Contractor and shall be incorporated into the construction in a timely manner, at no additional cost to the contract.
- J. These Specifications are arranged in accordance with the MasterFormat 2016, 35 Division format. The Specification is to be read as a whole. Items or work called for on one paragraph or Section, shall be applicable to the entire work, unless specifically indicated otherwise. Specific contract scopes shall be as determined by the General Contractor or Construction Manager.

1.3 DEFINITIONS:

- A. The following are definitions of words found in the various Sections of Divisions 21 and on the associated Fire Protection drawings:
1. "Concealed" shall indicate hidden from normal sight in furred spaces, shafts, ceiling spaces, walls, and partitions.
 2. "Exposed" shall indicate work normally visible, including work in Mechanical or Electrical equipment rooms, tunnels, and similar spaces.
 3. "Provide" (and tenses of "provide") – shall indicate "supply and install, complete in all respects, for a complete and fully functional installation."
 4. "Install" (and tenses of "install") – shall indicate "secure in position, make all final connections complete, test, verify and certify for a complete and fully functional installation."
 5. "Furnish" (and tenses of "furnish") – shall indicate "supply only, complete with all required accessories, mounting hardware, etc., for installation by others, or as spare "attic" stock for the Owner's future use."
 6. "Engineer" shall indicate person, firm or Corporation representing the Owner, and identified as such in the Contract Documents. The terms "Engineer" and "Architect" may be used interchangeably throughout the documents.
 7. "Authority Having Jurisdiction (AHJ)" shall indicate the organization, office, or individual responsible for enforcing the requirements of the applicable codes or standards in the location where the project is to be constructed.
 8. "BAS" shall indicate Building Automation System, and which shall also refer to by equivalent to references to "ATC" – Automatic Temperature Controls, "BMS" – Building Management System or "FMS" – Facility Management System. Any and all of these terms and acronyms may be used interchangeably to refer to the same functional system, specified under Divisions 21 - 25.

1.4 LAWS, REGULATIONS AND CODES:

- A. Perform all work in strict compliance with all laws, regulations, and/or codes applying, including all Federal, State, and local codes and any other authority having jurisdiction. Wherever drawings or specifications conflict with such regulations they shall be made to conform, and approval of the Design Professional obtained on such changes as may be involved.

1.5 QUALITY ASSURANCE:

- A. Comply with the requirements of the following codes and/or standards:
1. ANSI
 2. ASME
 3. ASTM
 4. UL
 5. NEMA
 6. AMCA
 7. NFPA
 8. ARI
 9. FM
 10. NEC
 11. IBC 2015
 12. IEBC 2015
 13. IMC 2015
 14. IECC 2015

- B. All packaged equipment shall be independently Third Party labeled as a system for its intended use by a Nationally Recognized Testing Laboratory (NRTL) in accordance with the OSHA Federal Regulations 29CFR1910.303 and .399, as well as NFPA Pamphlet #70 and National Electric Code (NEC), Article 90-7.

1.6 PERMITS, FEES, AND CERTIFICATES OF APPROVAL:

- A. Unless stated otherwise in General Conditions or Division 01, obtain and pay for all permits, fees, and licenses required, including those of utilities and Agencies. Provide copies to Design Professional in the quantity requested.
- B. "Fees" shall include connection charges construction costs, and other such charges by utility companies or service providers. Ascertain such charges during bidding period and include bid price.

1.7 REQUEST FOR INFORMATION (RFI):

- A. Contractor is responsible for submitting Requests for Information (RFI)s when discrepancies arise, logical discrepancies are found on the contract documents, or clarification is necessary. All RFIs must be clearly written and submitted with a suggested solution. All RFIs regarding changes to the intent indicated on plans must be accompanied by sketches, explanation, site pictures, and all other instruments necessary, to clearly convey the issue at hand and the suggested solution. The RFI process may only be utilized for legitimate purposes. RFIs may not be utilized to submit deviation or substitution requests, nor requesting confirmation of scope for items clearly defined on the contract documents, nor related to clarifications that should be resolved through the Contractor's coordination efforts. RFIs that do not comply will be summarily rejected and any delays caused as a result are the responsibility of the Contractor. In cases where the Contractor does not submit an RFI to clarify an issue and incorrectly proceeds, all work required to resolve such issues to be in compliance with the intent of the contract documents, as determined by the Engineer, shall be the Contractor's responsibility and at no additional cost to the project.
- B. The contractors are required to carefully examine all architectural and structural drawings for the building as well as all of the drawings for electrical trades, IT/AV/Security Trades, mechanical trades, and fire protection trades and be responsible for the proper fitting of all material and equipment into the building as planned and without interference with other piping, ductwork, conduit or equipment. Refer to the coordination drawing requirements. Proper judgment shall be exercised to secure best possible headroom, ceiling heights, door and window clearance, and space conditions throughout; to secure neat arrangement for piping, equipment, and conduit, and to overcome all local difficulties and interferences to best advantage. Approval for any and all changes to plans and specifications which may thus be incurred shall be obtained from the Design Professional before proceeding.

1.8 ALTERNATE PRICES:

- A. Refer to Division 01 Sections for list of Alternate Prices being requested for this project, and if they are to be Add or Deduct alternates.
- B. Where Alternate Prices are solicited, the alternate price shall include all work reasonably associated with the work to be priced as an alternate. Base bid conditions shall provide a complete, and fully functional installation, less the work associated with the alternate price.

1.9 RECORD DRAWINGS:

- A. Throughout the construction keep an accurate, up-to-date record of all deviations of the work between that as shown on the drawings and that which is actually installed.
- B. Obtain a complete set of prints of the Fire Protection drawings and note changes thereon. The design professional will provide the CAD files or Revit model for the contractor's use. Make a complete record in a neat and accurate manner, of all changes and revisions to original design which exist in completed work. As-Built markups shall be updated on a daily basis.
- C. Submit As-Built documents in electronic BIM file format. The project design files will be provided to the Contractor by the Design Professional following proper execution of the Document Release and Indemnity Form as provided by the Design Professional. The electronic files returned by the Contractor shall be fully compatible with the native software used by the Design Professional to create the original documents. In addition, submit a complete set of drawings in PDF format.
- D. The cost of preparing these record drawings shall be borne by the Contractor. When all revisions showing the work as finally installed are made, the prints and BIM files shall be submitted for review and approval by the Design Professional.
- E. Record drawings shall be delivered to Owner within 30 days of project Substantial Completion.

1.10 OPERATION AND MAINTENANCE MANUALS:

- A. Provide for the Owner's Use one (1) electronic copy in PDF format of a facility Operation and Maintenance Manual.
 - 1. Each hard copy Manual shall be bound in an extra heavy duty three-ring loose-leaf binder with the following title lettered on the front "Record and Information Manual (insert name of project)". No sheets larger than 8-1/2" x 11" shall be used, except sheets that may be neatly folded to 8-1/2" x 11" and used as a pullout.
- B. Provide the following information in each Manual:
 - 1. Cuts of all equipment with manufacturer's technical specifications. Material shall be manufacturer's brochures, catalog cuts, parts lists, wiring diagrams, etc. Also include approved shop drawings.
 - 2. Operation, Maintenance and Servicing Procedures. Include frequency of inspection, cleaning and adjusting and other attention as may be required in accordance with manufacturer's instructions.
 - 3. Copy of project Warranty.
 - 4. Contact name, telephone number and email address for obtaining replacement parts and service for all equipment.
 - 5. Copy of all individual equipment warranties.
 - 6. Copies of all required Test Reports.
 - 7. USB drive with all Special Systems drawings in both PDF and editable format.
 - 8. Electronic copy of all Owners Instruction and Training Sessions.
- C. Furnish qualified personnel to instruct the Owner's personnel in the maintenance and operation of all equipment and systems. Instructing personnel shall remain on the job continuously during working hours until such instruction is complete, but not less than 16 hours.

- D. A video recording in digital format of the operator training session shall be made during this training period and the digital video submitted to the Owner with the Operation and Maintenance Manuals.

1.11 WARRANTY:

- A. The material and workmanship of all parts of the mechanical installations specified herein and shown on the drawings shall be warranted unconditionally for a period of two (2) years from date of Project Substantial Completion against mechanical and electrical defects arising from faulty materials or workmanship. Either replacement or repairs shall be made promptly on any defective materials or workmanship without charge for materials, equipment, or labor during that period.
- B. Manufacturer's warranties on equipment provided under this contract shall be included in the operating and maintenance manuals.
- C. See specification section regarding restrictions on Early Use of Fire Protection Equipment.

1.12 CORRECTION OF WORK AFTER FINAL PAYMENT AND WARRANTY:

- A. This article is supplementary to Warranty Provisions of Division 01 and General Conditions.
- B. Final payment shall not relieve the Contractor of responsibility for correction of faulty equipment, materials, and workmanship and, unless otherwise specified, they shall remedy any defects due thereto and pay for damage to other work resulting therefrom, which shall appear within the warranty period specified above.
- C. Include warranties by the respective equipment manufacturers which shall be subject to the terms and time limits defined under these Divisions of Specifications.
- D. Warranties furnished by Sub-Contractor and/or equipment manufacturers shall be counter-signed by the related Prime Contractor for joint and/or individual responsibility for subject item.
- E. Manufacturers' equipment guarantees or warranties extending beyond the warranty period described herein shall be transferred to the Owner along with the Contractor's warranties.

1.13 COMMISSIONING:

- A. Commissioning: Division 21 Contractors and vendors shall be part of a total building and system commissioning effort as conducted by the Commissioning Agent. Each contractor shall provide a technician and tools required to assist and facilitate the commissioning agent, as outlined by the commissioning plan. Where applicable and required, the contractor shall secure and pay for a factory technician to be part of the startup, testing and commissioning team and efforts. Full scope of work and all related responsibilities will be defined in Commissioning documentation.
 - 1. All equipment shall be commissioned, and the operation of that equipment shall be checked by the installing contractor. Specific systems shall be commissioned when more than one contractor is involved in the installation or there is multiple system interface and control involved with that piece of equipment.
 - 2. The contractors shall check and verify all equipment nameplate data against the design parameters, prior to installation.
 - 3. The contractors shall submit a Spare Parts List for all equipment in the Maintenance and Operations Manuals to include, but not limited to the following:
 - a. Part Numbers.

- b. Part and Equipment Description.
 - c. Quantity of Parts Required.
 - d. Lubrication Requirements.
 - e. Full Warranty Information.
 - f. Complete Operation and Maintenance Manuals.
- B. Provide factory trained technician after successful startup, for on-site support. Allow for five (5) on-site for this. These days may not be consecutive.
- C. Provide six (6) additional site visits, after hours, after successful commissioning in the first year. For additional training and troubleshooting.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT:

- A. All installed materials and equipment shall be new and the best of their kind and shall conform to the grade, quality and standards specified herein.
- B. Unless otherwise specifically stated, all materials and equipment offered under these specifications shall be limited to products regularly produced and recommended by the manufacturer for the service intended. This material and equipment shall have capacities and ratings sufficient to amply meet the requirements of the project. The capacities and ratings shall be in accord with engineering data or other comprehensive literature made available to the public by the manufacturer and in effect at the time of opening of bids.
- C. Equipment shall be installed in accordance with manufacturer's instructions for type and quality of each piece of equipment used. These instructions shall be obtained from the manufacturer and shall be considered part of these specifications. Type, capacity, and application of equipment shall be guaranteed suitable to operate satisfactorily. No experimental material or equipment shall be permitted.

2.2 WORK INCLUDED:

- A. In addition to work described above under WORK DESCRIPTION, the work shall include but not necessarily be limited to the following:
 - 1. Install Owner's pre-purchased equipment. Refer to Article: FIRE PROTECTION EQUIPMENT BY OTHERS. Item (1) refers to pre-purchased equipment. Very few jobs have such equipment. Use this item with care, and ONLY if a prepurchase specification is to be written BY US for such equipment.
 - 2. Standpipe Systems.
 - 3. All miscellaneous pipe, fittings, valves, hangers, anchors, sleeves, plates, flashings, and appurtenances necessary for a complete installation, leaving same ready for service. Unless stated otherwise all control wiring from electrical disconnect to valves, controls, and equipment, requiring same.
 - 4. All excavation and backfilling required.
 - 5. Pipe and valve marking and tags. Painting as noted herein.
 - 6. All testing and adjusting of all systems.
 - 7. Instruction and equipment manuals.
 - 8. Instruction of Owner's representatives.

2.3 EXCAVATION AND BACKFILL:

- A. Provide all excavation and backfill required for work performed under this Contract.
- B. Excavation is unclassified and includes without limitation the excavation and removal of all material encountered.
- C. Backfill with clean, rock and debris-free earth. Use hand shovel to work backfill around conduit or encasement and against sides of trench. Mechanically tamp backfill to density of undisturbed adjacent earth. Remove excess excavated material from site.
- D. Provide all shoring, bracing, barricades, dewatering, etc.
- E. All surfaces disturbed by earthwork shall be restored to their original condition using materials and methods to match the existing surfaces.

2.4 PUMPING:

- A. Provide pumping equipment to pump all water to prevent it from collecting in trenches, basement areas, and any other excavations necessary to carry out contract requirements. Prepare run-off trenches as required to pump water into and use surplus earth to form dam at top of excavation to run back surface water.

2.5 CHASES AND OPENINGS:

- A. Provide information to the appropriate trades regarding size and location of all openings and chases as required for the installation of this Fire Protection Work.
- B. Patching and repair of finishes will be by the General Contractor.
- C. Provide sleeves for pipes passing through poured concrete decks, footings, walls, etc. Cut all openings for piping passing through precast concrete or existing concrete or masonry. Such holes shall be cut with core drill or similar equipment. They shall not be cut with hammer and chisel, or with any power tool depending on impact for its cutting power.

2.6 CUTTING AND PATCHING:

- A. Provide all cutting and patching required for work performed under this Contract. No holes may be cut or drilled in structural members without prior approval of Owner's Representative. Cutting shall be done by mechanics skilled in their respective trades.
- B. No cutting that may impair the strength of the building construction shall be done. No holes may be drilled in or attachments welded to the beams or other structural members without prior approval from the Owner's Representative. All work shall be done by mechanics skilled in their trade.
- C. All patching shall be done in a manner to match appearances and quality of existing surfaces.
- D. Provide sleeves for pipes passing through poured concrete decks, footings, walls, etc. Cut all openings for piping passing through precast concrete or existing concrete masonry. Such holes shall be cut with core drill or similar equipment. They shall not be cut with hammer or chisel, or with any power tool depending on impact for its cutting power.

- E. For holes and openings in pre-cast concrete, 2-1/2" round and above, or 2-1/2" and above on longest side, prepare a drawing for the Design Professional's approval for same to be pre-cast in the factory; for holes and openings smaller than above, prepare a drawing for the Design Professional's approval for same to be cut, cored, or drilled in the field by the Fire Protection trade.

2.7 CONCRETE:

- A. Provide concrete work required for work performed under this Contract. Coordinate with work shown on Structural Drawings.
- B. Concrete shall have a compressive strength of 3,000 psi minimum at twenty-eight days. Placing of reinforcing steel and concrete shall be done according to the recommendations of the American Concrete Institute and Concrete Reinforcing Steel Institute, and all materials shall conform to American Society for Testing Materials Specifications, applicable to this work. Equipment pads shall be properly dowelled in with floor construction and shall have sloped bevels on all horizontal and vertical edges.
- C. Form work shall be of sufficient strength to maintain desired shape during pouring of concrete and tight enough to prevent leakage of the grout through joints.
- D. Submit shop drawings for approval showing dimensions, reinforcing, and dowelling.
- E. Provide at the time of pouring concrete, all necessary anchor bolts. Anchor bolts shall be the hook type, of proper size and length to suit the equipment. Anchor bolts shall be set in pipe sleeves of approximately twice the bolt diameter and one half the embedded length of the bolt. Assume full responsibility for proper emplacement of the bolts.
- F. Drop-in wedge anchor bolts or self-drilling anchors may be used in place of hook bolts. Minimum embedment in concrete of wedge anchor bolts shall be in accordance with manufacturer's instructions. Wedge anchor bolts shall be manufacturer by Phillips Drill Co. or USM Corp. Self-drilling anchors shall be manufactured by Phillips Drill Co.
- G. After equipment is set in place and bolted down, any space between equipment base and floor slab or foundation shall be completely filled with non-shrink grout equal to Master Builders Co., Ltd. Embeco 153 grout.

2.8 ELECTRICAL WORK AND MOTORS:

- A. All electrical work shall be done in strict accordance with the requirements of the National Electrical Code and the Electrical Specifications. All electrically operated equipment shall bear an Underwriter's Laboratories label where labeling service is available for that type of equipment.
- B. All motor frames shall be grounded. Electric power, control and grounding connections shall be factory wired to an outlet box or terminal strip enclosure on the apparatus for easy connection by the Electrical Contractor.
- C. All motors shall be designed and constructed in accordance with the latest standards of the IEEE and NEMA and shall meet UL requirements. Motors shall run quietly under all operating conditions.
- D. See Division 26 Specification for additional details.

2.9 WIRING FOR CONTROL SYSTEMS:

- A. This Article applies to wiring used for Fire Protection systems and similar types of control systems associated with work of Division 21.
- B. All wiring for control systems shall comply with Article 725 of the National Electrical Code, (NEC) or with Articles 760, 800, or 820 for control systems integrated into systems covered by those Articles.
 - 1. Particular attention shall be given to the requirements of the NEC for testing and labeling cables for use in plenums, risers, and other air-handling spaces.
- C. All wiring for control systems shall be of a type recommended by the system manufacturer and be installed in accordance with systems manufacturer's instructions.
- D. Cables must be in raceways when run through inaccessible ceilings, walls, or chases. Comply with Division 26 Specifications, for types of raceways required and their installation requirements. Cables run on surfaces within 8' of finished floor must be in raceways where exposed to physical damage. Cables in mechanical spaces must be in raceways.
 - 1. Where cables enter or leave raceways, provide insulated bushing or protective grommet.
- E. Cables may be run without raceways above accessible ceilings; in hollow stud partitions; and where properly supported in unfinished spaces without ceilings.
- F. Cables run without raceways in concealed locations or unfinished spaces shall be supported by bridle rings or similar hangers attached to the building structure at maximum 5'-0" centers. Hangers and/or cables shall not be supported from pipes, ducts, or similar equipment. Cables shall not be supported by lying on or across framing members or structural elements.
- G. Where cable is run exposed in finished areas, it shall be supported by bridle rings and beam clamps at maximum 4' intervals. All cables running along a given beam, joist, or truss shall be bundled together and run parallel to each other. Bundle shall be tied together at 2' intervals with T&B "Ty-raps" or equal nylon cable tie. Ty-raps shall be exposed one foot on either side of bridle ring supports. Cables shall be pulled as tight as possible and run as straight as possible.
 - 1. Where cables bend, bends shall be 90 degrees; parallel cables shall have symmetrical turns. Bending radius shall be no smaller than manufacturer's specification for level of cable involved. Individual cables shall be supported with metal straps listed for the purpose. All cables shall be run parallel with or perpendicular to building lines, plumb and true. Cable loops connecting to boxes or fittings shall be as short and neat as possible.
 - 2. See details on Electrical Drawings for general information regarding cable support. All cables run on steel structure will be painted to match steel; cable supports, ties, etc., must be installed prior to painting.
 - 3. Cables shall be maintained at a spacing of 6" from 120 V and higher voltage AC conductors, unless installed in a grounded metallic raceway.
- H. Wiring with or without raceways shall be run continuously between terminal boxes and outlets. All splices shall be made in NEMA 1 boxes with terminal strips or other acceptable connectors and permanent labels to identify each wire and cable, both entering and leaving the box.
- I. A separation of not less than 6" shall be maintained to heated pipelines.

- J. Cable run above hung ceilings used for environmental air shall be specifically listed and labeled for the use or shall be installed in a raceway.
- K. Wiring run without raceways through rated walls, floors and partitions shall be run in sleeves. All such sleeves shall be packed with fire-rated material.
- L. Wiring for different systems shall be grouped and run separately from other systems and shall be identified as to the system it serves.
- M. Where equipment to be provided is controlled with line voltage devices (thermostats, speed controllers, timers, etc.), these devices shall be furnished to the electrical contractor for mounting and wiring of same.
- N. All electrical wiring in connection with the BAS shown on the electrical drawings shall be installed by the Electrical Contractor. Any wiring not shown but required for proper operation of the automatic temperature control system, shall be performed by the Control Contractor and shall be in complete accordance with National Electrical Code, latest edition, and the Electrical Contract Specifications.

2.10 FLASHING AND ROOFING WORK:

- A. The Contractor shall perform all cutting, patching, and sealing of existing roofs as required for the installation of all work under this Contract.
- B. The contractor bears the complete responsibility for maintaining and obtaining the watertight integrity of the affected areas of the roofs both during and after the completion of construction.
- C. The Contractor shall provide all base flashings, counter flashings, and hot applied roofing materials necessary to properly flash and seal the roofs as required and to prevent any water or moisture leakage whatsoever from occurring as a result of this work.
- D. Unless noted otherwise, all flashings shall be minimum 24-gauge galvanized steel. Base flashings shall have minimum 4" roof flanges on all sides. Flanges of all base flashings shall be secured and stripped into existing roofing in accordance with the best practices and methods of the roofing trade for a watertight installation.
- E. All joints and seams of all flashings shall be continuously soldered.
- F. After installation, all exposed metal surfaces of base flashings shall be given two (2) applications of roofing coating.
- G. All roofing work shall be performed by first class mechanics experienced in the roofing trade.
- H. Contractor must exercise extreme care so as not to damage existing roofs while working thereon and they shall provide protection planking and plywood as required to achieve this result. Any damage to the existing roofs and their watertight integrity caused as a result of work being performed under this Contract shall be properly repaired by the Contractor to the satisfaction of and at no cost to the Owner.
- I. Refer to drawings for additional flashing details and roofing work required.

2.11 SUBSTITUTIONS:

- A. Equipment may be shown or specified in several ways:

1. Manufacturer and catalogue or model number with the words "no substitutions," "no equal," "(manufacturer) only," or words of similar respect. Contractor shall furnish the specified item.
 2. Several manufacturers and model numbers listed; or one manufacturer and model number, followed by "equals by (mfr A), (mfr B), (mfr C)," or words of similar respect.
 - a. If one of the manufacturers is listed on the drawings, that manufacturer shall be considered the basis of design. If none is so listed, the first manufacturer named in the Specification shall be considered the basis of design.
 - b. Where manufacturer's or supplier's name, style and catalog numbers are mentioned in the description of material and equipment in the specifications or on the drawings, it is to be understood that they are for the purpose of setting a standard.
 - c. If Contractor elects to furnish equipment other than the basis of design, they shall verify capacities, physical size, weight, electrical requirements, methods of connection to other parts of the system, and all other relevant data. Contractor shall be responsible for informing the Design Professional of all changes required to other equipment, spaces, structure, or systems in order to install the substituted equipment. They shall furnish all required shop drawings or sketches required for Design Professional to evaluate the required changes and shall be responsible for all costs associated with such changes, including costs of design or engineering, if such are necessary, and costs of other trades.
 - d. Accompany the request for substitution review with a table of comparisons listing pertinent features of both the specified and proposed materials including performance data, weight, material of construction, overall length, width, height dimensions, space required for replacement or maintenance access, motor type, horsepower, voltage, phase service factor, and noise levels. Review of proposed substitution will not be made until receipt of the complete comparison tabulation.
 3. Where manufacturer's or supplier's names are listed in conjunction with the manufacturer or supplier that is basis of design, they are given to approve the firm name only. Equipment or material submitted by such firms must meet the detailed technical specifications written for the respective item. Contractor shall be responsible for verifying capacities, physical sizes, weights, electrical requirements, and methods of connection to other parts of the system, etc. Contractor shall furnish all required shop drawings for equipment, and for its connection and installation.
- B. If any substituted items are submitted after contracts have been awarded, and there is any question of equality of such items, samples may be required to be submitted both for the item specified and that to be substituted, or further proof of equality may be required to the entire satisfaction of the Design Professional. In no case shall additional remuneration be allowed because of the rejection of a substitute.
- C. When the equipment is relocated to a place other than that shown on the drawings, or when equipment other than that specified is used, the Contractor shall pay the extra cost of required revisions such as structural steel, concrete, electrical, piping, etc.
- D. The Design Professional's costs to evaluate substitutions and to revise Drawings and Specifications because of substitutions will be paid by the Contractor.
- 2.12 SHOP DRAWINGS:
- A. Refer also to Division 01.

- B. Furnish shop drawings, catalog cuts, performance data and other required data to the Design Professional for approval for all material and equipment specified hereinafter. Sufficient data shall be submitted to show compliance with the requirements of the plans and specifications. All shop drawings submitted shall be first checked and corrected before submitting for approval. Approval for shop drawings by the Design Professional will not relieve the Contractor from responsibility for errors or omissions therein. All such errors or omissions must be made good by the Contractor irrespective of any approval by the Design Professional.
- C. It is the responsibility of the manufacturer's representative and the installing contractor to thoroughly review all shop drawing equipment submittals and state in writing that the products meet or exceed the design specifications and design intent as indicated on the contract documents, prior to submitting them for review by the engineer.
- D. The General Contractor or Construction Manager shall review and stamp all shop drawings noting their review process has taken place and that the shop drawings are in compliance with the design documents, prior to submitting them for review by the engineer. Any shop drawings found to not be in compliance shall be returned to the contractor stating such, with a copy of the statement (only) forwarded to the engineer.
- E. On submissions beyond the initial one, clearly identify all of the changes made from the initial submittal those requested by the Design Professional. The Design Professional will review only those changes they requested and those identified by the Contractor.
- F. The Engineer will review three submissions (one original submission and up to two revised submissions) on any single component requested for review. If the contractor and/or vendor fail to comply with the drawings, specifications, and/or review comments and additional submissions are required, the cost for review and processing of those submissions will be borne by the contractor.
- G. The design documents are based and coordinated on the scheduled manufacturers. Any substitutions of products or materials (from those approved and listed in the specifications) must be thoroughly coordinated by the submitting contractor. This includes but is not limited to power, space, structural, control and performance requirements.
- H. Shop drawings required shall include, but not necessarily be limited to, the following:
 - 1. Shop drawings, cuts and catalogue information showing appearance, dimensions, performance, weight, etc., of all equipment, appurtenances, etc.
 - 2. Schedules of all materials showing type and manufacturer.
 - 3. Wiring diagrams and schematics for equipment.
 - 4. All special equipment and systems.
 - 5. Any special constructions.
 - 6. Other shop drawings as may be requested.
- I. Digital files of mechanical work will not be provided for the purpose of shop drawing preparation. Digital files of architectural plans, elevations, sections, etc. may be available for background purposes; it is the responsibility of the Contractor to confirm availability prior to bid.
- J. Shop drawings shall be submitted in a timely manner, taking due account of time requirements for processing, correcting, and distributing the shop drawings to all persons or trades requiring the information, as well as time required for manufacture of the equipment. Design Professional will not be responsible for construction delays resulting from late submission of shop drawings, nor for delays caused by the need to correct and resubmit shop drawings which were not correct,

which involved substituted equipment, or otherwise required review, correction, and resubmission.

- K. If Contractor elects to proceed to install equipment for which approved Shop Drawings have not been received, they do so at their own risk; Design Professional is not obligated to accept such equipment or work, nor will Design Professional be liable for claimed costs or delays required by correction of such work.
- L. Identify each submittal, including shop drawings, catalog data, test reports, operation and maintenance manuals, and record documents, with the following data:
 - 1. Buyer's name.
 - 2. Project name.
 - 3. Project location.
 - 4. Buyer's purchase order number.
 - 5. Reference specification order number.
 - 6. Name of contractor making the submittal.
 - 7. Revision level of submittal and date of revision.
- M. For equipment, provide the following information on each submittal:
 - 1. Equipment tag number.
 - 2. Equipment description.
 - 3. Equipment manufacturer's contact information.
 - 4. Local equipment representative's contact information.
- N. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristic, finishes for materials, and installation and startup instructions for each type of product indicated.
 - 1. Each control device labeled with setting or adjustable range of control.
- O. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Schematic flow diagrams showing all controlled equipment and control devices.
 - 2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
 - 3. Details of control panel faces, including controls, instruments, and labeling.
 - 4. Written description of sequence of operation.
 - 5. Trunk cable schematic showing programmable control unit locations and trunk data conductors.
 - 6. Listing of connected data points, including connected control unit and input device.
 - 7. System graphics indicating monitored systems, data point addresses, and operator notations.
 - 8. System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
- P. Shop Drawings shall be submitted and shall consist of a complete list of equipment and materials, including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions. Shop drawings shall also contain complete wiring, routing, schematic diagrams, tag number of devices, software descriptions, calculations, and any other details required to

demonstrate that the system will function properly. Drawings shall show proposed layout and installation of all equipment and the relationship to other parts of the work.

- Q. Shop Drawings shall be approved before any equipment is installed. Therefore, shop drawings must be submitted in time for review so that all installations can be completed per the project completion schedule. Ten (10) working days shall be allowed for submittals to be reviewed by the Engineer.
- R. All drawings shall be reviewed after the final system checkout and updated or corrected to provide "as-built" drawings to show exact installation. All shop drawings will be acknowledged in writing before installation is started and again after the final checkout of the system. The system will not be considered complete until the "as-built" drawings have received their final approval. The Contractor shall deliver a complete set of "as-built" drawings.
- S. On submissions beyond the initial one, clearly identify changes made from the initial submittal other than those requested by the Design Professional. The Design Professional will review only those changes they requested and those identified by the Contractor.

Shop Drawing Review Comment Definitions

A> No Exception Taken:

The shop drawing or equipment submittal as submitted is approved without exception. No changes or corrections required. The materials, equipment or system submitted can be released for fabrication and construction. No Further Submission Required.

B> Make Corrections Noted:

The shop drawing or equipment submittal as submitted is not completely correct but is approved as noted. Make the corrections noted on the shop drawing or submittal. The materials, equipment or system submitted can be released for fabrication and construction once the corrections have been made. The submittal must be corrected and resubmitted for record unless noted by "E: Resubmit". See "E: Resubmit definition below.

C> Submit Specified Item:

The shop drawing or equipment submittal as submitted is missing a component of the system that it represents or is not of the approved and specified manufacturers. Submit the missing or incorrect item. The materials, equipment or system submitted cannot be released for fabrication and construction.

D> No Further Submission Required:

The shop drawing or equipment submittal as submitted is approved as noted. No changes or corrections required. The materials, equipment or system submitted can be released for fabrication and construction. No Further Submission Required.

E> Resubmit:

The shop drawing or equipment submittal as submitted is not approved. The shop drawing or equipment submittal needs significant corrections and does require another submission to verify that the comments and changes have been incorporated. Make the corrections noted on the shop drawing or submittal. The materials, equipment or system submitted cannot be released for fabrication and construction.

F> Rejected:

The shop drawing or equipment submitted is not as specified or a non-approved manufacturer or product and rejected.

G> Resubmit for Record Only:

Make the corrections noted on the shop drawing or submittal. The shop drawing or equipment submittal as submitted is approved with minor exception. Changes or corrections are required. The materials, equipment or system submitted can be released for fabrication and construction.

PART 3 - EXECUTION

3.1 VISIT TO SITE:

- A. Before submitting bid, visit the site of the work and be thoroughly familiarized with the conditions affecting the work. No extra payment will be allowed on account of extra work made necessary by failure to do so.

3.2 WORKMANSHIP:

- A. All work shall be installed in a first class, neat and workmanlike manner by mechanics skilled in the trade involved. All details of the installation shall be mechanically correct. Should the Design Professional direct removal, change, or installation of any equipments or systems not installed in a neat and workmanlike manner, such changes shall be made by the Fire Protection Contractor at no expense to the Owner.
- B. Equipment shall be installed in strict accordance with manufacturer's instructions for type and capacity of each piece of equipment used. The Contractor shall obtain these instructions from the manufacturer and these instructions shall be considered part of these Specifications.
- C. Drawings are generally indicative of the work to be installed, but do not indicate all bends, fittings, and specialties which may be required, or the exact locations of all piping and equipment. Contractor shall investigate structure and finish conditions affecting their work and arrange their work; accordingly, furnishing such fittings as may be required to meet such conditions. Contractor is responsible for exercising proper judgment to arrange their work and materials so as to avoid interference with other trades.
 - 1. Riser diagrams and schematics generally indicate equipment to be used in various systems involved. This information may or may not be duplicated on the plans, but equipment shown on either plans or riser diagrams and schematics shall be provided as if shown on both.
 - 2. All grades, elevations, dimensions, and clearances of equipment shown on drawings are approximate and shall be verified at site.
 - 3. Where work or equipment is referred to in singular terms, such reference shall be deemed to apply to as many items of work or equipment as required to complete entire installation.

3.3 LINES AND GRADES:

- A. Lay out work and establish heights and grades for work in strict accordance with the intent expressed by the drawings and all the physical conditions at the building and be responsible for the accuracy of same.

3.4 FIELD MEASUREMENTS:

- A. Before ordering any material or doing any work, verify all measurements at the building and site and be responsible for the correctness of same. No extra compensation will be allowed on account of differences between actual dimensions and measurements and those indicated on the drawings. Any difference which may be found shall be submitted to the Design Professional for consideration before proceeding any further with the work.

3.5 DELIVERY OF EQUIPMENT:

- A. Be responsible for delivery of equipment, unload and store in a manner not to interfere with the operation of other trades. Additional expense incurred because of equipment or material delivery delays shall be assumed by the responsible Contractor.

3.6 RESTRICTIONS ON EARLY USE OF FIRE PROTECTION EQUIPMENT:

- A. The Fire Protection equipment provided under this contract shall not be operated prior to the completion of construction of the building for reasons other than testing and balancing of the systems, unless specifically directed and/or approved by the Owner. This specifically prohibits the use of permanent equipment for the purposes of ventilating, heating, and dehumidifying the building while under construction.
- B. Should a contractor choose to use any component of the permanent Fire Protection system for purposes other than stated above, they shall assume full responsibility for replacing or repairing any equipment damaged as a result of the use and pay all costs associated with the action required to make the equipment in "like new" conditions at the end of the project. This includes cleaning of ducts and coils, replacement of motors, extension of warranties, payment of design professional fees required to investigate and enforce this requirement, and the correction of any other detrimental conditions which is determined by the design professionals to be related to the early use of the equipment.
- C. Should the early use of equipment result in manufacturer's warranty being void, the contractor shall assume the cost of furnishing an equivalent warranty to the owner.
- D. Should pump motors be operated during construction, any motor determined by the owner or design professional to be exposed to airborne construction dust, such as generated by drywall sanding, shall be inspected by an independent 3rd party for damage. The costs of all required corrective actions shall be borne by the contractor responsible for the operation of the equipment.

3.7 PROTECTION OF WORK:

- A. All work, equipment and materials shall be protected at all times.
- B. All piping openings shall be closed with caps or plugs during installation. All equipment shall be tightly covered and protected against dirt, water, plaster, paint and other foreign material or mechanical injury during entire progress of installation. Make good all damage caused either directly or indirectly by workmen employed to fulfill requirements of the Fire Protection Work.

3.8 REMOVAL OF RUBBISH:

- A. During the course of construction, periodically remove from the premises all rubbish resulting from work of this trade so as to prevent its accumulation. At the completion of the work contemplated under these Specifications remove from the building and site all rubbish and accumulated materials of whatever nature not caused by the other trades and leave work, and

equipment free of all foreign matter including plaster, cement, and paint and leave in a clean, orderly, acceptable, and usable condition

3.9 COORDINATION WITH OTHER TRADES:

- A. Work in conjunction with each of the other trades to facilitate proper and intelligent execution of work with minimum interference.
- B. Carefully examine all architectural and structural drawings for the building and drawings for electrical trade and other mechanical trades and be responsible for the proper fitting of all material and equipment into the building as planned and without interference with other piping, ductwork, conduit, or equipment. Proper judgment shall be exercised to secure best possible headroom, door and window clearance, and space conditions throughout; to secure neat arrangement for piping, equipment, and conduit; and to overcome all local difficulties and interferences to best advantage. Approval for any and all changes to plans and specifications which may thus be incurred shall be obtained from the Design Professional before proceeding.
- C. Contractor shall prepare preliminary sheet-metal shop drawings suitable for use in coordinating their work with the work of other trades. The Mechanical Contractor shall prepare and furnish CAD files of drawings at $3/8" = 1'-0"$ scale illustrating the coordination with all trades. Drawing shall indicate equipment access requirements, piping, ductwork, and conduit in relation to all structural elements of the construction, including floor elevations; steel locations, size, and elevations; partitions locations; door locations and direction of swing; and all other information required to assure coordination of the electrical, sheet-metal and piping trades and fire protection in relation to the Architectural function of the project. Coordination meetings shall be held under the supervision of the Owner's Construction Manager and General Contractor. Each trade shall have proper representation at all coordination meetings for the purpose of detailing, on a print of the coordinated drawing mentioned above, the exact location and routing of their work. After the conclusion of the coordination at the working meetings, each trade shall sign the coordinated print, copies of which shall be distributed by the GC to all contractors and parties concerned including the Owner. A print of each final coordination CAD drawing with the participants contractor's "signoff" signatures appended shall be submitted to the design professional for record.
- D. If contractor installs work so as to cause interference with work of other trades, they shall make necessary changes in work to correct the condition without extra charge.
- E. Dimensional layout plans of equipment rooms shall be made showing all bases, pads and inertia blocks required for mechanical equipment. Include dimensions of bases, bolt layouts, details, etc.
- F. Contractor shall furnish all necessary templates, patterns, etc. for installing work and for purpose of making adjoining work conform, furnish setting plans and shop details to other trades as required.

3.10 COORDINATION OF CONTROL EQUIPMENT:

- A. The Fire Protection Contractor shall furnish all starters, push buttons for local or remote control, controllers, pressure switches, aquastats, thermostats, float switches or similar items together with all appurtenances and accessories required to operate the equipment furnished under these specifications and necessary to perform the operating functions as specified, shown on the drawings, or otherwise required.

- B. Refer to Schedule of Control Equipment on Drawings for type of controls required. The Electrical Contractor will mount and provide power-wiring for all starters and will furnish and install all other safety switches or other line-disconnecting or protective devices. Where the starter and/or safety switch is an integral part of the equipment assembly, the assembly shall be furnished with the wiring complete between starter, controller and motor and the Electrical Contractor will make power connections only.
 - C. All control wiring to automatic-operated switches, pressure switches, aquastats or other devices which actuate the starter or other items associated with the systems shall be furnished, installed, and wired by the Fire Protection Contractor. The Electrical Contractor will supply 120V electric power to the control panels for these special systems to the extent shown on Electrical Drawings. All other wiring (including additional power circuit if required) shall be the responsibility of the Fire Protection Contractor.
 - D. The Fire Protection Contractor shall carefully check the current characteristics available to each location before ordering motors.
 - E. If procurement requirements necessitate a change in voltage, phase, horsepower or other characteristics of any motor, the Fire Protection Contractor shall obtain approval of such change from the Design Professional and shall be responsible for necessary arrangements for notifying the Electrical Contractor, and shall pay the costs, if any, required by the change, including Engineering costs.
 - F. All electrical equipment furnished and installed under this contract shall be furnished with full complement of control equipment, control wiring, conduit, and all other items necessary for satisfactory operation.
 - G. The Electrical Contractor will complete all electrical power connections, through the disconnect and/or thermal cutouts, starter, and motor terminals. They will be responsible for final power connections.
 - H. The Electrical Contractor will be responsible for proper rotation of three phase equipment.
 - I. All electrical work, equipment and material furnished under this Section shall be furnished and installed in accordance with Division 26 Electrical Specifications.
 - J. All panels, relays, terminal boxes, contactors, circuit breakers, safety switches, motor starters and similar items shall be identified by Name, Function and/or Control. Nameplates shall be at least 1" x 3" with characters not less than 1/4". They shall be made of two laminated black plastic sheets bonded with a middle sheet of white plastic and characters engraved in one black sheet to the depth of the white plastic. A typewritten list of Nameplates shall be submitted to the Design Professional for approval before ordering same.
- 3.11 EXPANSION OF PIPING:
- A. All piping connections shall be made so as to allow for perfect freedom of movement of piping during expansion and contraction, without springing or creating air pockets which will impair the flow of the water through the system. Install expansion loops as shown on the drawing or as required. Expansion loops shall be made with swing joints, bends or long offsets as necessary. Provide expansion guides.

3.12 ANCHORS AND GUIDES:

- A. Anchors shall be provided where shown and/or required for the proper control of stress in piping due to expansion.

3.13 ACCESS:

- A. All equipment and valves requiring maintenance or adjustment must be accessible. Items located above ceilings shall be located above accessible portions of the ceiling or above access panels provided by this Contractor. Manufactured items with internal components requiring access (whether integral with the enclosure or not) shall be provided with access panels.

3.14 CONCRETE HOUSEKEEPING PADS:

- A. Refer also to "Concrete" article in Part Two of this specification section.
- B. Concrete housekeeping pads shall be provided for all floor mounted fire protection equipment located in mechanical spaces. Where pads are shown on the drawings, they are representative only and do not necessarily indicate all locations where pads are required.
- C. Pads shall be not less than 6" above the floor and shall extend not less than 6" beyond the equipment base in all directions, unless otherwise noted on the drawings.
- D. Pads provided for air handling equipment shall be of sufficient height to allow for proper trap depth in the cooling coil condensate removal system.

3.15 FIRE STOPPING:

- A. All penetrations through fire-resistance-rated floor, fire resistance rated, floor/ceiling assemblies and roof construction and through fire-resistance-rated walls and partitions shall be fire stopped.
- B. Penetrations to be fire stopped include both empty openings and those containing cables, pipes, ducts, conduits, and any other items.
- C. Fire rating of sealed penetrations shall meet or exceed the rating of the assembly being penetrated.
- D. Materials shall be installed in accordance with manufacturer's recommendations and their UL listing.

3.16 SEISMIC RESTRAINTS: Edit as noted below. Delete where restraints are not required.

- A. All mechanical equipment and material required by applicable Codes to be installed or supported in accordance with seismic restraint criteria shall be installed in accordance with this Article. This applies to equipment or materials specified in other Division 21 Specification sections as well as to materials specified in this section.
- B. Contractor shall provide hangers, isolators, supports, restraints, etc., from a single manufacturer of such products. Such manufacturer shall certify in writing that the products provided by them meet the requirements specified or calculated by the Seismic Engineer for the specific application. Manufacturer shall be responsible for:
 - 1. Determining restraint sizes and locations.
 - 2. Providing restraint products to meet the requirements of the specific application.

3. Guaranteeing performance of the products supplied.
 4. Providing installation instructions, drawings and field supervision to the contractor to ensure proper installation of the products; and
 5. Certifying correctness of installation of the products upon completion and identifying for correction any items or areas not properly applied.
- 3.17 FIRE PROTECTION EQUIPMENT BY OTHERS: Edit the entire article as required to match the prepurchase specification. A copy of the prepurchase specification should always be included for reference. Throughout this article, modify the term "Owner's Representative" if not appropriate. In J, modify warrantee period if not correct.
- A. Certain equipment listed below has been purchased FOB the job site by the Owner's Representative.
 - B. The successful Contractor bidding to these documents shall be designated the "Installing Contractor" herein and shall perform the actions specified in this section. The Contractor from whom the Owner's Representative has pre-purchased the equipment shall be designated the "Furnishing Contractors" herein.
 - C. The Owner's Representative reserves the right to purchase any one of the manufacturers specified for any pre-purchased equipment. During the bidding period, the Installing Contractor shall contact each of the specified manufacturers for the pre-purchased equipment and familiarize themselves with all installation requirements.
 - D. The following will be furnished by the Furnishing Contractor to the Owner's Representative. The Installing Contractor shall obtain same from the Owner's Representative.
 1. Shipping manifest.
 2. Copies of dimensioned equipment and maintenance instructions.
 3. Copies of installation instructions.
 4. Copies of operating and maintenance instructions.
 - E. The work to be done by the Installing Contractor shall include, but not necessarily be limited to the following:
 1. Accept the equipment at the point of delivery at the job site and check shipping manifest. Inspect for damage jointly with Furnishing Contractors and Owner's Representative and notify transport carrier and Owner accordingly.
 2. Rig equipment to place of installation.
 3. Assemble, support and install equipment.
 4. Install accessories, materials, etc. furnished loose with equipment.
 5. Provide complete mechanical connections.
 6. Provide electrical work internal to the pre-purchased equipment.
 7. Perform all operations and work necessary to place equipment into proper operation. The Owner will perform no work related to the installation and startup of pre-purchased equipment.
 - F. Field wiring will be done under Division 26 of the Specifications.
 - G. As an aid to the Installing Contractor, the Specifications for all equipment that will be pre-purchased are attached following these specifications. However, it is the Installing Contractor's responsibility to ascertain the manufacturer, type, model, and details of the equipment pre-purchased.

1. Refer to the attached Specifications for description of Furnishing Contractor's list of work and responsibilities.
- H. List of Owner pre-purchased equipment:
- I. The Furnishing Contractors have included in their bids the services of field representatives to test and start-up the equipment. In cooperation with these field representatives, the Installing Contractor shall check all equipment for proper connections, for alignment, for proper operation, etc.
 - J. Furnishing Contractors have included in their bids a one-year warrantee of all equipment. The Installing Contractor shall guarantee on their letterhead that they warrants the installation for the same time period covered by the Furnishing Contractors' Warrantees. They shall further explicitly state therein that they will be responsible for coordinating the correction of any Warrantee items with the Furnishing Contractors and will be responsible for the Furnishing Contractors' timely performance of their Warrantees.

END OF SECTION

SECTION 210005

COORDINATION DRAWING REQUIREMENTS FOR FIRE PROTECTION

PART 1 - GENERAL

1.1 COORDINATION DRAWINGS

- A. All mechanical, electrical, plumbing, fire protection, telecommunications, and ATC subcontractors will be required to use AutoCAD (CAD) format. Coordination drawings will be distributed via email and/or disk.

1.2 ABOVE CEILING AND NO CEILING OVERHEAD INSTALLATION

- A. The Mechanical Contractor shall furnish minimum 1/4 inch scale CAD electronic background drawings of the sheet-metal shop drawings, for incorporation of plumbing and mechanical piping services. All ductwork and piping systems shall be thoroughly dimensioned as to location and height above finished floor. Each different system will be drawn in a different color. Upon conclusion of the various systems coordination with the Sheet-Metal Contractor, the composite drawing shall be distributed by the Construction Manager for contractor coordination. All lighting fixture locations will be "ghosted in" by the Sheet-Metal Contractor for coordination of the same. The Sheet-Metal Contractor shall prepare a title box on each drawing which allows space for the signature of the authorized individual from the Sheet-Metal, HVAC Piping, Plumbing, Fire Protection, Electrical, Telecommunications and ATC firms, with the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

NOTE: The composite drawing is in addition to separate shop drawings to be submitted at the conclusion of the coordination process.

- B. At the conclusion of each composite drawing coordination process, the Construction Manager shall be notified by the Mechanical Contractor Project Manager. The Mechanical Contractor Project Manager shall then schedule an on-site coordination meeting for the purpose of signing off on the respective drawing. The Mechanical Contractor shall not be authorized to release any material for fabrication or installation until the composite drawing signature process is executed or until Construction Manager authorizes, in writing, a portion of the work to proceed.
- C. The Mechanical Contractor shall print a weekly status log and maintain a file for the project on this process. Each subcontractor is responsible to submit and coordinate their work with the Construction Manager and Mechanical Contractor.
- D. The Fire Protection Contractor shall overlay their complete piping system on a composite background drawing furnished by the Mechanical Contractor. The Fire Protection Contractor shall utilize a different color from that previously used by the HVAC and Plumbing draftsmen. The Fire Protection Contractor shall cooperate in the coordination process by the relocation of their piping as required to facilitate coordination. When completed, Sprinkler Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the

entire coordination process, the Fire Protection Contractor shall be responsible for attending a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signatures to the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

NOTE: The composite drawing is in addition to a separate sprinkler piping shop drawing to be submitted at the conclusion of the coordination process.

- E. The Electrical Contractor shall be responsible to overlay their major conduit racks and equipment, as well as verifying all lighting fixture locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. All conduits larger than 2 inch shall be documented. When completed, Electrical Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Electrical Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signature to the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

- F. The Plumbing Contractor will be responsible to overlay their major piping racks and equipment, as well as verifying all plumbing fixture locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. When completed, Plumbing Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Plumbing Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signature to the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

- G. The Telecommunication Contractor will be responsible to overlay their major communication racks and cable tray, as well as verifying locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. When completed, Telecommunication Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Telecommunication Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signature to the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

- H. Provide survey and coordination of underground plumbing for verification of location.

- I. Drawings, if available, may be obtained electronically from the Architect through the Construction Manager.
- J. The Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC Contractors shall receive hard copies of all drawings.
- K. The Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC Contractors shall review all drawings and advise if any additional drawings are needed.
- L. The Mechanical Trade Contractor shall take the lead and develop a drawing list for submissions and a submission schedule coordinated with the construction activities. The drawings shall be developed in a sequential fashion so as to no delay installation of the work or the overall project schedule. The lead Mechanical trade contractor shall include a master key plan so that the area of each drawing can be readily identified as to the location within each building. The Plumbing trade contractor shall lead the underground coordination and the HVAC trade contractor shall lead the balance of the coordination work. The drawing list and schedule shall be forwarded to the Construction Manager for review.
- M. Pursuant to Construction Manager approval of the list and schedule, the Mechanical trade contractor shall provide to all participants the latest plans in a timely fashion in accordance with their schedule.
- N. Prior to the start of the work, each subcontractor shall forward an insulation schedule to the Construction Manager M.E.P. Coordinator. The schedule shall show the size and thickness of each type of insulation and its intended use.

1.3 ACCESS FLOOR INSTALLATION

- A. Coordination drawings for systems to be installed in the access floor shall be prepared in the same manner as described for the overhead installation.

1.4 SHEET-METAL / PIPING / ATC / ELECTRICAL ACCESS / MAINTENANCE CLEARANCES

- A. As soon as practical, the Mechanical trade contractor shall prepare layout drawings (not less than 3/8 inch scale) of all ductwork and piping. These drawings shall show all WALL FIRE RATINGS, registers, grilles, diffusers, and similar features, as well as locations of all valves, dampers, damper operators and other items requiring access for maintenance. It shall also be the responsibility of the Mechanical trade contractor to show on these drawings; beams with bottom elevations, ceiling heights, wall-to-wall dimensions, partitions, columns, windows, doors, electric lighting layouts as shown on the reflected ceiling plans, acoustical ceiling grid, and other major architectural and structural features as shown on the General Construction Drawings. All dimensions should be from centerlines of columns. All required access to equipment for service and/or required for NEC code required clearances shall be shown in a dotted zone.
- B. The Mechanical trade contractor, upon completion of their work, shall email their data back to the Plumbing trade contractor and copy all participants. The Plumbing trade contractor shall download the mechanical data and incorporate, by separate layer, their own routing, as well as other areas requiring access for service and maintenance to determine their relationship and possible interferences with the mechanical, architectural, or structural features to be performed as part of the work.

- C. The Plumbing trade contractor shall then email their data to the Electrical trade contractor and copy all participants. The Electrical trade contractor shall download the drawing and incorporate, by separate layer, their own routings, as well as the depth of all light fixtures, access panels, etc., as required to determine the relationship and possible interferences with plumbing, mechanical, architectural, or structural items to be installed as part of the overall work. The Electrical trade contractor shall be responsible to verify that the electrical lighting layout shown on these drawings is correct and to make corrections and additions of all other light fixtures as required. In areas where no mechanical work occurs, but where other crowded electrical installations are evident, the Electrical trade contractor shall prepare similar drawings.
- D. The Electrical trade contractor shall then email the Fire Protection trade contractor and copy all participants. The Fire Protection trade contractor shall download the drawing and incorporate, by separate layer, their own routings, as well as other areas requiring access for service and maintenance, to determine their relationship and possible interferences with the mechanical, electrical, plumbing, and architectural or structural items to be installed as part of the overall work.
- E. The Mechanical trade contractor shall provide one composite set of reproducible drawings and forward them to the Construction Manager. This composite shall then be reviewed during meetings determined by the Construction Manager, at which all subcontractors including their subcontractors, as required by the Construction Manager, shall be represented to review, and resolve any real or apparent interference or conflicts.
- F. In the preparation of all the final composite drawings, large scale details, as well as cross and longitudinal sections shall be made as required to fully delineate all conditions. Particular attention shall be given to the locations, size and clearance dimensions of equipment items, shafts, and similar features. The final composite drawings shall include the locations of all controls, tie-ins, connections for other subcontractor's work, and pipe and duct insulation as required.
- G. Final composite drawings shall then be signed off by each trade subcontractor indicating their acceptance and approval of the indicated routings and layouts and their relationship with the adjoining or contiguous work of all subcontracts. Thereafter, no unauthorized deviations shall be permitted. If deviations are made without the knowledge and agreement of Construction Manager and other affected trade contractors, the work in question shall be subject to removal and correction at no additional cost.
- H. In preparing the composite drawings, minor changes in duct, pipe or conduit routings that do not affect the intended function may be made as required to avoid space conflicts, when mutually agreed. Items may not be resized, exposed items relocated, or items run exposed when not intended, without approval. No changes shall be made in any structural members or architectural features which affect the function or aesthetics of the buildings. If conflicts or interferences cannot be satisfactorily resolved, the Engineer shall be notified, and their decision obtained.
- I. After final composite drawings have been accepted and approved, and signed by ALL subcontractors, the Mechanical trade contractor shall provide and distribute one sepia and two prints to each of the subcontractors, and one sepia and four prints each to Construction Manager. Subcontractors requiring further prints for their own distribution will possess sepias to accomplish same. The original signed-off mylars shall be sent to Construction Manager for permanent possession.

- J. The record copies of final composite drawings shall be retained by each subcontractor as a working reference. All shop drawings, prior to their submittal to Construction Manager, shall be compared with the composite drawings and developed accordingly by the subcontractor responsible. Any revisions to the composite drawings, which may become necessary during the process of the work, shall be noted by all subcontractors, and shall be neatly and accurately recorded on the record copies. Each trade contractor shall be responsible for the up-to-date maintenance of their own record copies of the composite drawings and to keep one copy available at the site. The composite drawings and any subsequent changes thereto, shall be utilized by each subcontractor in the development of their as-built drawings. NOTE: The coordination drawings may be used with appropriate changes as as-builts and changes to title block.
 - K. Preparation of coordination drawings shall commence as soon as possible after award of the subcontract. The coordination drawings may lack complete data in certain instances pending receipt of equipment drawings, but sufficient space shall be allotted for the items affected. When final information is received, such data shall be promptly inserted on the composite by that trade contractor.
 - L. Coordination is the responsibility of all trade contractors. Construction Manager will call meetings, weekly, or as required, which subcontractors must attend to avoid delay. Failure to attend shall require the trade contractor to field run the work not coordinated. No extra compensation will be paid to any trade contractor for relocating any duct, pipe, conduit, or other material that has been installed without proper coordination. If the installation of any uncoordinated work or improper installation or coordinated work necessitates additional work by other subcontractors, at the cost of such additional work shall be assigned to the trade contractor responsible as determined by Construction Manager.
 - M. All changes in the work of any subcontract shall be shown on the composite drawings.
 - N. All work on the coordination composite drawings shall be performed by competent CAD operators, in a clear legible manner. Each trade contractor shall execute a typical drawing activity in no more than three working days. It shall be the responsibility of each subcontractor to supply a sufficient number of CAD operators so as not to delay the coordination process. Construction Manager and Engineer shall be the judge of the acceptability of the drawings.
 - O. The composite drawings shall not be used for as-built drawings. (See Paragraph above)
 - P. It shall be further understood that each trade contractor's specified submittals shall be transmitted for approval during the coordination period in order that the project encounter no delays.
 - Q. The Mechanical trade subcontractor shall pre-coordinate all control equipment locations with the designated ATC trade subcontractor and indicate it on the composite document.
- 1.5 REQUIREMENTS
- A. All Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC trade contractors shall be required to use AutoCAD (CAD) format. Coordination drawings shall be distributed via email or diskettes. ALL EMAILS SHALL BE COPIED TO CONSTRUCTION MANAGER, ENGINEER, AND PROJECT MANAGER.
 - B. The Sheet-Metal trade contractor shall prepare a title box on each drawing which allows space for the signature of the authorized individual from the sheet-metal, HVAC, piping, plumbing, sprinkler, electrical and ATC firms with the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

- C. The Mechanical trade contractor shall not be authorized to release any material for fabrication or installation until the composite drawing signature process is executed or until Construction Manager authorizes, in writing, a portion of the work to proceed.
- D. The Mechanical Contractor shall print a weekly status of all emails sent and received and maintain a hard copy file for use at the coordination "sign-off" meetings. Each subcontractor is required to check emails daily.
- E. Submittals: Once the coordination process has been completed, the coordination drawings shall be submitted to the Engineer for review. A single-color plot, as well as three blueprint copies of the drawings shall be submitted for review. The color plot shall delineate between the various disciplines by utilizing different color pens for each system.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 210517

SLEEVES AND SLEEVE SEALS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Sleeves.
 - 2. Stack-sleeve fittings.
 - 3. Sleeve-seal systems.
 - 4. Grout.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- B. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- C. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.2 STACK-SLEEVE FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Jay R. Smith Mfg. Co.
 - 2. Zurn Industries, LLC.
- B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Advance Products & Systems, Inc.
 - 2. CALPICO, Inc.
 - 3. GPT Industries.
 - 4. Metraflex Company (The).
 - 5. Proco Products, Inc.
- B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 - 1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 2. Pressure Plates: Carbon steel.
 - 3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.4 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
 - 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 - 1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 - 2. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
1. Cut sleeves to length for mounting flush with both surfaces.
 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 5. Using grout, seal the space around outside of stack-sleeve fittings.
- B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
1. Exterior Concrete Walls above Grade:
 - a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves.
 - b. Piping NPS 6 and Larger: Galvanized-steel wall sleeves.
 2. Exterior Concrete Walls below Grade:

- a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 6 and Larger: Galvanized-steel wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs-on-Grade:
- a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
4. Concrete Slabs above Grade:
- a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
 - b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.
5. Interior Partitions:
- a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
 - b. Piping NPS 6 and Larger: Galvanized-steel-sheet sleeves.

END OF SECTION

SECTION 210800

FIRE PROTECTION SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 RELATED SECTIONS

- A. Division 21 – Fire Suppression
- B. Division 23 – Heating, Ventilating and Air Conditioning
- C. Section 019113 – General Commissioning Requirements

1.3 REQUIRMENTS

- A. The Commissioning process requires the participation of Division 21, Fire Protection, to ensure that all systems fulfill the functional and pre-functional requirements set forth in these construction documents. The general commissioning requirements and coordination are detailed in Section 019113. Division 21, Fire Protection, shall fulfill commissioning responsibilities assigned to division 21 in accordance with Section 019113.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PRE-FUNCTIONAL CHECKLISTS

- A. Pre-functional checklists assist in the process to document that the equipment and systems are installed properly.
- B. The contractor will be provided with construction checklists from the CA for completion. The contractor shall complete the checklists as provide the CA with completed copies in accordance with 019113.
- C. See attached for a sample pre-functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.2 FUNCTIONAL PERFORMANCE TESTING

- A. Intent of functional performance testing is to prove thru functional test procedures proper system operation.

- B. The contractor will be provided with functional performance test procedures to perform while CA witnesses. The contractor shall perform functional tests in accordance with 019113, requirements of the specification section, code requirements, or requirements of the authority having local jurisdiction.
- C. See attached for a sample functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.3 PREFUNCTIONAL CHECKLISTS AND FUNCTIONAL PERFORMANCE TESTING

- A. Pre-Functional Checklists and Functional performance testing procedures will be performed on the following system types. (Pre Functional and Functional performance testing requirements are in addition to and do not replace any testing required elsewhere in Division 21 or by applicable codes.) Equipment specifically marked as such below shall be provided with start-up of equipment by factory-authorized service representative.
 - 1. Fire Protection System and equipment; fire alarm system interfaces with HVAC systems

3.4 SAMPLE CHECKLISTS

- A. See Attached.

END OF SECTION

SAMPLE ONLY

Contractor Checklist and Functional Test Procedures

FIRE PROTECTION SYSTEMS

1. Participants

Discipline	Name	Company
CxA		
Mechanical		
Controls		
TAB		
Plumbing		
Electrical		
Fire Protection		
Date Returned to CxA		

2. Prerequisite Checklist

Check	Description
<input type="checkbox"/>	The above equipment and systems integral to them are complete and ready for functional testing.
<input type="checkbox"/>	All control system functions for this and all interlocking systems are programmed and operable per contract documents, including final setpoints and schedules with debugging, loop tuning and sensor calibrations completed.
<input type="checkbox"/>	All A/E punchlist items for this equipment corrected.
<input type="checkbox"/>	Safeties and operating ranges reviewed.
<input type="checkbox"/>	Schedules and reviewed <ul style="list-style-type: none">This checklist does not take the place of the manufacturer's recommended checkout and startup procedures.Items that do not apply shall be noted with the reasons on this form (N/A = not applicable, BO = by others).Contractors assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off.

3. Installation Checks

Check	
Zone Valves	
Sealed	<input type="checkbox"/>
Locked	<input type="checkbox"/>
Tamper Switches	<input type="checkbox"/>
Position	<input type="checkbox"/>
Operation	<input type="checkbox"/>
Supervisory	<input type="checkbox"/>
Alarm Valves	
Pressure gauges	<input type="checkbox"/>
Main drain/test	<input type="checkbox"/>
Trim piping per manufacturer's instructions	<input type="checkbox"/>
Isolation valve	<input type="checkbox"/>
Backflow Prevention	
Reduced Pressure Backflow Preventer	<input type="checkbox"/>
Reduced pressure Detectors Assembly	<input type="checkbox"/>
Double Check Valve Assembly	<input type="checkbox"/>
Double Check Detector Assembly	<input type="checkbox"/>
Fire Department Connection	
Brass Finish	<input type="checkbox"/>
Brass caps and chains	<input type="checkbox"/>
Check valve	<input type="checkbox"/>
Waterflow Alarms	
Tied into fire alarm control panel	<input type="checkbox"/>
Provided at alarm valve riser	<input type="checkbox"/>
Valves, Piping	
Isolation valves installed per drawings	<input type="checkbox"/>
Pipe fittings complete and pipes properly supported	<input type="checkbox"/>
Pipes properly labeled	<input type="checkbox"/>
Piping system properly flushed	<input type="checkbox"/>
No leaking apparent around fittings	<input type="checkbox"/>
Valves properly labeled	<input type="checkbox"/>
Risers clamps	<input type="checkbox"/>
Test connections	
Instrumentation installed according to specification (pressure gages, test valves, etc.)	<input type="checkbox"/>
Clean up of equipment completed per contract documents	<input type="checkbox"/>
Inspectors test connections provided at all zones with equivalent sprinkler orifice size	<input type="checkbox"/>
Maintenance access acceptable for components	<input type="checkbox"/>

4. Operational Checks

Check	Equip Tag➔	Test Results Functional Y/N
Inspectors test valve opened flowing equivalent of one sprinkler, activation of flow switch and automatic activation of alarm at fire alarm control panel at Zone # 1		
Inspectors test valve opened flowing equivalent of one sprinkler, activation of flow switch and automatic activation of alarm at fire alarm control panel at Zone # 2		
Inspectors test valve opened flowing equivalent of one sprinkler, activation of flow switch and automatic activation of alarm at fire alarm control panel at Zone # 3		
Inspectors test valve opened flowing equivalent of one sprinkler, activation of flow switch and automatic activation of alarm at fire alarm control panel at Zone # 4		
Activation of tamper switch and automatic activation of alarm at fire alarm control panel at all valve locations		

SECTION 211313

FIRE PROTECTION PIPING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Pipes, fittings, and specialties.
 - 2. Specialty valves and connections.
 - 3. Sprinklers.
 - 4. Standpipes.
 - 5. Alarm devices.
 - 6. Pressure gauges.

1.3 DEFINITIONS

- A. Standard-Pressure Piping: System piping designed to operate at working pressure of 175-psig maximum.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include diagrams for power, signal, and control wiring.
- C. Delegated-Design Submittal: For standpipe systems, sprinkler systems, and fire pump systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Sprinkler systems, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Plumbing piping.
 - 2. HVAC hydronic piping.
 - 3. Items penetrating finished ceiling include the following:

- a. Lighting fixtures.
 - b. Air outlets and inlets.
 - B. Qualification Data: For qualified Installer.
 - C. Approved Sprinkler Piping Drawings: Working plans, prepared by Nicet IV according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
 - 1. Sprinklers shall be referred to on drawings and shall be specifically identified by the listed manufacturer's style or series designation. Trade names and abbreviations are not permitted.
 - D. Welding certificates.
 - E. Grooved joint products shall be shown on drawings and product submittals and shall be specifically identified with the applicable Victaulic style or series number.
 - F. Fire-hydrant flow test report.
 - G. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
 - H. Field quality-control reports.
- 1.6 CLOSEOUT SUBMITTALS
- A. Operation and Maintenance Data: For wet-pipe sprinkler systems and specialties to include in emergency, operation, and maintenance manuals.
- 1.7 MAINTENANCE MATERIAL SUBMITTALS
- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.
- 1.8 QUALITY ASSURANCE
- A. Installer Qualifications:
 - 1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility (Nicet IV). Base calculations on results of fire-hydrant flow test.
 - a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
 - B. Welding Qualifications: Qualify procedures and operators according to 2010 ASME Boiler and Pressure Vessel Code.

- C. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
 - 1. All castings used for coupling housings, fittings, valve bodies, etc., shall be date stamped for quality assurance and traceability.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, and weld ends.
 - 3. Set valves open to minimize exposure of functional surfaces.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.
- D. Protect flanges and specialties from moisture and dirt.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:
 - 1. NFPA 13.
- B. UL Listed: Valves shall be listed in UL's "Online Certifications Directory" under the headings listed below and shall bear UL mark:
 - 1. Main Level: HAMV - Fire Main Equipment.
 - a. Level 1: HCBZ - Indicator Posts, Gate Valve.
 - b. Level 1: HLOT - Valves.
 - 1) Level 3: HLUG - Ball Valves, System Control.
 - 2) Level 3: HLXS - Butterfly Valves.
 - 3) Level 3: HMER - Check Valves.
 - 4) Level 3: HMRZ - Gate Valves.
 - 2. Main Level: VDGT - Sprinkler System & Water Spray System Devices.
 - a. Level 1: VQGU - Valves, Trim and Drain.
- C. FM Global Approved: Valves shall be listed in its "Approval Guide," under the headings listed below:

1. Automated Sprinkler Systems:
 - a. Indicator posts.
 - b. Valves.
 - 1) Gate valves.
 - 2) Check valves.
 - a) Single check valves.
 - 3) Miscellaneous valves.
- D. Source Limitations for Valves: Obtain valves for each valve type from single manufacturer.
- E. ASME Compliance:
 1. ASME B16.1 for flanges on iron valves.
 2. ASME B1.20.1 for threads for threaded-end valves.
 3. ASME B31.9 for building services piping valves.
- F. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- G. NFPA Compliance: Comply with NFPA 24 for valves.
- H. Valve Pressure Ratings: Not less than the minimum pressure rating indicated or higher as required by system pressures.
- I. Valve Sizes: Same as upstream piping unless otherwise indicated.
- J. Standard-Pressure, Fire-Suppression Standpipe System Component: Listed for 175-psig minimum working pressure.
- K. High-Pressure, Fire-Suppression Standpipe System Component: Listed for 350-psig working pressure.
- L. Fire-suppression standpipe design shall be approved by authorities having jurisdiction.
 1. Minimum residual pressure at each hose-connection outlet is as follows:
 - a. NPS 2-1/2 Hose Connections: 100 psig.
- M. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design wet-pipe sprinkler systems.
 1. Available fire-hydrant flow test records indicate the following conditions:
 - a. Date: July 26, 2022
 - b. Time: 9:00 PM
 - c. Performed by: Nitsch Engineering/Wakefield Water Department
 - d. Location of Observation Fire Hydrant R: Existing NEMT Guard House
 - e. Location of Flow Fire Hydrant F: Existing NEMT Main Entrance, Hemlock Rd
 - f. Static Pressure at Observation Fire Hydrant R: 85 psi
 - g. Residual Pressure at Observation Fire Hydrant R: 57 psi
 - h. Measured Flow at Flow Fire Hydrant F: 904.2 gpm

2. Sprinkler system design shall be approved by authorities having jurisdiction.
 - a. Margin of Safety for Available Water Flow and Pressure: Include a 10 percent safety factor for losses, include losses through water-service piping, valves, and backflow preventers.

2.2 STEEL PIPE AND FITTINGS

- A. Standard-Weight Schedule 40, Galvanized- and Black-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method, Standard-Weight Schedule 40 in NPS 2" and smaller.
- B. Schedule 10, Black-Steel Pipe: ASTM A 135/A 135M or ASTM A 795/A 795M, Schedule 10 in NPS 8 and smaller to 2½".
- C. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.
- D. Steel Couplings: ASTM A 865/A 865M, threaded.
- E. Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
- F. Malleable- or Ductile-Iron Unions: UL 860.
- G. Cast-Iron Flanges: ASME 16.1, Class 125.
- H. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
 1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or EPDM rubber gasket.
 - a. Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.
 - b. Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Face Flanges: Ring-type gaskets.
 2. Metal, Pipe-Flange Bolts and Nuts: Carbon steel unless otherwise indicated.
- I. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.
 1. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- J. Grooved-Joint, Steel-Pipe Appurtenances:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Basis of Design: Victaulic Company.
 - b. Upon Approval of Engineer:
 - 1) Victaulic Company.
 - 2) Anvil International.
 - 3) Tyco Fire & Building Products LP.

2. Pressure Rating: 175-psig minimum.
3. Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting, with dimensions matching steel pipe. Short-pattern in applicable sizes, with flow equal to standard pattern fittings. Basis of Design: Victaulic FireLock.
4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and ATSM 449 compliant bolts and nuts.
 - a. Rigid: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with NFPA-13, fully installed at visual pad-to-pad offset contact. Couplings that require gapping of bolt pads or specific torque ratings for proper installation are not permitted. Installation-Ready, for direct stab installation without field disassembly. Basis of Design: Victaulic Style 009N, 109 or 107N.
 - b. Flexible: Use in locations where vibration attenuation and stress relief are required. Basis of Design: Victaulic Style 177 Installation-Ready, and Style 77.
5. Installation-Ready™ fittings for Schedule 10 grooved end steel piping in fire protection applications sizes NPS 2½. Fittings shall consist of a ductile iron housing conforming to ASTM A-536, Grade 65-45-12, with Installation-Ready™ ends, orange enamel coated. Fittings complete with prelubricated Grade "E" EPDM Type 'A' gasket; and ASTM A449 electroplated steel bolts and nuts. System shall be UL listed for a working pressure of 300 psi and FM approved for working pressure 365 psi.

2.5 HANGERS AND SUPPORTS

- A. Furnish and install hangers and supports to attach all pipes securely to the structure in correct alignment and pitch, to prevent vibration and to effectively care for expansion and contraction. Parts in contact with copper pipe or tubing shall be copper plated, and chrome plated for chrome plated piping.
- B. Spacing for horizontal piping shall be as follows:
 1. Copper Tubing: 6 feet on centers for 1-1/4 inch and smaller, 10 feet on centers for 1-1/2 inch and larger and as per NFPA 13 and 14.
 2. Steel Pipe: 6 feet on center for 1-1/4 inch and smaller, 10 feet on center for 1-1/2 inch and larger and as per NFPA 13 and 14.
- C. Vertical lines shall be adequately supported at their bases by a suitable hanger placed in the horizontal line near the riser and clamped at every 10 foot interval vertically.
- D. Vertical lines shall be supported at each floor level if the floor-to-floor dimension is greater than 10 feet, and if this is approved by the pipe manufacturer's guidelines for that type of pipe joint system.
- E. Piping supported from structural steel shall have beam clamps with restraining straps and hangers consisting of threaded rod and hangers. Carpenter-Patterson No. 1-A steel band hanger for piping 2 inch and smaller and No. 100 steel clevis hanger for piping 2-1/2 inch and larger, sized to suit for continuous insulation, with pipe shields.
- F. Where piping is required to be hung from other than the building structure, such as precast or metal decking, submit proposed method of support to the structural engineer for approval prior to installation.

- G. All hangers and devices for buried piping shall be hot dipped galvanized.
- H. All anchors that will be used in the "tension" zone of a slab, shall be approved by the manufacturer for that application.
- I. Post installed and cast-in-place anchors shall meet ACI 318, Appendix D. In addition, post-installed anchors shall be pre-qualified per the test methods of Acceptance Criteria 193 for mechanical anchors and AC 308 for adhesive anchors.

2.6 FIRE-DEPARTMENT CONNECTION

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. American Fire Hose & Cabinet.
 - 2. Elkhart Brass Mfg. Co., Inc.
 - 3. GMR International Equipment Corporation.
 - 4. Guardian Fire Equipment, Inc.
 - 5. Potter Roemer LLC.
 - 6. Venus Fire Protection Ltd.
- B. Standard: UL 405.
- C. Type: Flush, for wall mounting.
- D. Pressure Rating: 175 psig minimum.
- E. Body Material: Corrosion-resistant metal.
- F. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
- G. Caps: Brass, lugged type, with gasket and chain.
- H. Escutcheon Plate: Rectangular, brass, wall type.
- I. Outlet: With pipe threads.
- J. Body Style: Horizontal.
- K. Outlet Location: As required.
- L. Escutcheon Plate Marking: Similar to "AUTO SPKR", "AUTO SPKR & STANDPIPE" or "STANDPIPE."
- M. Finish: Polished chrome plated.
- N. Outlet Size: As required.
- O. At the low point near each fire department connection, provide a 90-degree elbow with drain connection to allow for localized system drainage to prevent freezing. Basis of Design: Victaulic FireLock #10-DR.

2.7 HOSE CONNECTIONS

A. Nonadjustable-Valve Hose Connections:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brooks Equipment Co., Inc.
 - b. Elkhart Brass Mfg. Co., Inc.
 - c. Fire Protection Products, Inc.
 - d. Fire-End & Croker Corporation.
 - e. GMR International Equipment Corporation.
 - f. Guardian Fire Equipment, Inc.
 - g. Kennedy Valve Company; a division of McWane, Inc.
 - h. Kidde Fire Fighting; A UTC Business Unit.
 - i. Mueller Co.
 - j. NIBCO INC.
 - k. Potter Roemer LLC.
 - l. Tyco Fire & Building Products LP.
 - m. Viking Corporation.
 - n. Wilson & Cousins Inc.
 - o. Zurn Industries, LLC.
2. Standard: UL 668 hose valve for connecting fire hose.
3. Pressure Rating: 300 psig minimum.
4. Material: Brass or bronze.
5. Size: NPS 1-1/2 or NPS 2-1/2, as indicated.
6. Inlet: Female pipe threads.
7. Outlet: Male hose threads with lugged cap, gasket, and chain. Include hose valve threads according to NFPA 1963 and matching local fire-department threads.
8. Pattern: Angle or gate.
9. Finish: Rough chrome-plated.

2.8 ESCUTCHEONS

- ### A. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.

2.9 SPECIALTY VALVES

- ### A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
- ### B. Pressure Rating:
1. Standard-Pressure Piping Specialty Valves: 175-psig minimum.
 2. High-Pressure Piping Specialty Valves: 300-psig.
- ### C. Body Material: Cast or ductile iron.
- ### D. Size: Same as connected piping.
- ### E. End Connections: Flanged or grooved.

2.10 PRESSURE REDUCING VALVES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ames.
2. CLA-VAL Automatic Control Valves.
3. Elkhart Brass Mfg. Co., Inc.
4. Fire-End & Croker Corporation.
5. Guardian Fire Equipment, Inc.
6. Bermad
7. Tyco Fire & Building Products LP.
8. Viking Corporation.

B. Description:

1. UL Listed
2. Pressure Rating: 300 psig minimum.
3. Material: Ductile Iron ASTM 65-45-12.
4. Seat: Stainless Steel
5. Spring: Stainless steel
6. Elastomers: Buna-N
7. Pilot: Brass Body with stainless steel internals
8. Inlet: Flanged or grooved.
9. Outlet: Flanged or grooved.
10. Pattern: Globe.
11. Finish: Fused epoxy.

2.11 TWO-PIECE BALL VALVES WITH INDICATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Ames.
2. Victaulic.
3. Elkhart Brass Mfg. Co., Inc.

B. Description:

1. UL 1091, except with ball instead of disc and FM Global standard for indicating valves (ball type), Class Number 1112.
2. Minimum Pressure Rating: 175 psig.
3. Body Design: Two piece.
4. Body Material: Forged brass or bronze.
5. Port Size: Full or standard.
6. Seats: PTFE.
7. Stem: Bronze or stainless steel.
8. Ball: Chrome-plated brass.
9. Actuator: Worm gear or traveling nut.
10. Supervisory Switch: Internal or external.
11. End Connections for Valves NPS 1 through NPS 2: Threaded ends.
12. End Connections for Valves NPS 2-1/2: Grooved ends.

2.12 IRON BUTTERFLY VALVES WITH INDICATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Basis of Design: Victaulic Company.
 2. Upon approval of the engineer:
 - a. Victaulic Company.
 - b. NIBCO INC.
 - c. Viking Corporation.
 - d. Zurn Industries, LLC.
 - a. Tyco Fire & Building Products LP.
- B. Description:
1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 112.
 2. Minimum Pressure Rating: 300 psig.
 3. Body Material: Cast or ductile iron with nylon, EPDM, epoxy, or polyamide coating.
 4. Seat Material: Pressure-responsive EPDM.
 5. Stem: Stainless steel, offset from the disc centerline to provide complete 360-degree circumferential seating.
 6. Disc: Ductile iron, and EPDM or SBR coated.
 7. Actuator: Weatherproof actuator housing with worm gear or traveling nut.
 8. Supervisory Switch: Internal or external.
 9. Body Design: Lug or wafer Grooved-end connections.
 10. Basis of Design: Victaulic Series 705.

2.13 CHECK VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Basis of Design: Victaulic Company.
 2. Upon approval of the engineer:
 - a. Victaulic Company.
 - b. NIBCO INC.
 - c. Viking Corporation.
 - d. Watts; a Watts Water Technologies Company.
 - e. Tyco Fire & Building Products LP.
- B. Description:
1. Standard: UL 312 and FM Global standard for swing check valves, Class Number 1210.
 2. Minimum Pressure Rating: 175 psig.
 3. Type: Single swing check.
 4. Body Material: Cast iron, ductile iron, or bronze.
 5. Clapper: Bronze, ductile iron, or stainless steel.
 6. Clapper Seat: Brass, bronze, or stainless steel.
 7. Hinge Shaft: Bronze or stainless steel.
 8. Hinge Spring: Stainless steel.
 9. End Connections: Flanged, grooved, or threaded.

10. Basis of Design: Victaulic Series 717.

2.14 IRON OS&Y GATE VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Basis of Design: Victaulic Company.
2. Upon approval of the engineer:
 - a. Victaulic Company.
 - b. American Cast Iron Pipe Company.
 - c. NIBCO INC.
 - d. Tyco Fire & Building Products LP.
 - e. Watts: A Watts Water Technology Company.

- B. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron, or bronze.
5. Wedge Seat: Cast or ductile iron, or bronze.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Flanged, Grooved, or Threaded.
10. Basis of Design: Victaulic Series 771.

2.15 NRS GATE VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Basis of Design: Victaulic Company.
2. Upon approval of the engineer:
 - a. Victaulic
 - b. American Cast Iron Pipe Company.
 - c. NIBCO INC.
 - d. Zurn Industries, LLC.
 - e. Tyco Fire & Building Products LP.

- B. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron.
5. Wedge Seat: Cast or ductile iron, or bronze.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.

8. Supervisory Switch: External.
9. End Connections: Flanged, Grooved, or Threaded.
10. Basis of Design: Victaulic Series 772.

2.16 TRIM AND DRAIN VALVES

A. Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames.
 - b. Conbraco Industries, Inc.
 - c. Fire Protection Products, Inc.
 - d. Fire-End & Croker Corporation.
 - e. Flowserve Corporation.
 - f. FNW; Ferguson Enterprises, Inc.
 - g. Jomar Valve.
 - h. KITZ Corporation.
 - i. Legend Valve & Fitting, Inc.
 - j. Metso Automation USA Inc.
 - k. Milwaukee Valve Company.
 - l. NIBCO INC.
 - m. Potter Roemer LLC.
 - n. Red-White Valve Corporation.
 - o. Tyco Fire & Building Products LP.
 - p. Victaulic Company.
 - q. Watts; a Watts Water Technologies company.
 - r. Zurn Industries, LLC.
2. Description:
 - a. Body Design: Two piece.
 - b. Body Material: Forged brass or bronze.
 - c. Port size: Full or standard.
 - d. Seats: PTFE.
 - e. Stem: Bronze or stainless steel.
 - f. Ball: Chrome-plated brass.
 - g. Actuator: Handlever.
 - h. End Connections for Valves NPS 1 through NPS 2-1/2: Threaded ends.
 - i. End Connections for Valves NPS 1-1/4 and NPS 2-1/2: Grooved ends.

B. Alarm Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis of Design: Victaulic Company.
3. Upon approval of the engineer:
 - a. Victaulic
 - b. Reliable Automatic Sprinkler Co., Inc. (The).
 - c. Venus Fire Protection Ltd.
 - d. Viking Corporation.
 - e. Tyco Fire & Building Products LP.

4. Standard: UL 193.
5. Design: For horizontal or vertical installation.
6. Valve internal components shall be replaceable with valve in the installed position.
7. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gauges, retarding chamber, and fill-line attachment with strainer.
8. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
9. Drip Cup Assembly: Pipe drain with check valve to main drain piping.
10. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
11. Basis of Design: Victaulic Series 751.

C. Pre-Assembled Fire Protection Valves

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Victaulic Company.
 - b. Tyco Fire & Building Products LP.
2. Type: Pre-assembled Dry valve, mounted in a steel cabinet with red ASA-61 electrostatically applied polyester powder coating.
 - a. Cabinet shall have field removable access panels on three sides to allow for ease of valve maintenance, servicing, and installation.
3. UL listed and FM approved, with all materials and wiring conforming to NFPA requirements.
4. Provided with a Series 728 ball valve or Series 705 butterfly shutoff valve with pre-wired supervisory switches, the sprinkler system fire protection valve, alarm line pressure switches, air supervisory pressure switches, alarm pressure switch and pressure gauges for proper operation.
5. All external electrical connections shall be able to be connected through a factory provided conduit connection to an enclosure inside of the cabinet.
6. Water inlet, system supply, and drain connections shall be grooved for ease of installation.
7. 300 psi pressure rating.
8. Basis of Design: Victaulic FireLock® Series 745 Fire-Pac.

D. Pressure-Reducing Hose Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bermad.
 - b. CLA-VAL Automatic Control Valves.
 - c. Tyco Fire & Building Products LP.
 - d. Viking Corporation.
 - e. Zurn Industries, LLC.
2. UL 668 hose valve, with integral UL 1468 reducing device.
3. Pressure Rating: 300 psig minimum.
4. Material: Brass or bronze.
5. Inlet: Female pipe threads.
6. Outlet: Threaded with or without adapter having male hose threads.

7. Pattern: Angle or gate.
8. Finish: Polished chrome-plated.

E. Automatic (Ball Drip) Drain Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Reliable Automatic Sprinkler Co., Inc. (The).
 - b. Tyco Fire & Building Products LP.
 - c. Viking Corporation.
2. Standard: UL 1726.
3. Pressure Rating: 175-psig minimum.
4. Type: Automatic draining, ball check.
5. Size: NPS 3/4.
6. End Connections: Threaded.

2.17 PIPING SPECIALTIES

A. Branch Outlet Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis of Design: Victaulic Company.
3. Upon approval of the engineer:
 - a. Victaulic
 - b. Anvil International.
 - c. National Fittings, Inc.
 - d. Tyco Fire & Building Products LP.
4. Standard: UL 213.
5. Pressure Rating: 175-psig minimum.
6. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
7. Type: Mechanical-tee and -cross fittings.
8. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
9. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
10. Branch Outlets: Grooved, plain-end pipe, or threaded.
11. Basis of Design: Victaulic Style 920 / 920N.

B. Flow Detection and Test Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis of Design: Victaulic Company.
3. Upon approval of the engineer:
 - a. Victaulic
 - b. AGF Manufacturing Inc.
 - c. Reliable Automatic Sprinkler Co., Inc. (The).
 - d. Viking Corporation
 - e. Tyco Fire & Building Products LP.

4. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
5. Pressure Rating: 175-psig minimum.
6. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
7. Size: Same as connected piping.
8. Inlet and Outlet: Threaded or grooved.

C. Branch Line Testers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Elkhart Brass Mfg. Co., Inc.
 - b. Fire-End & Croker Corporation.
 - c. Potter Roemer LLC.
 - d. Tyco Fire & Building Products LP.
2. Standard: UL 199.
3. Pressure Rating: 175 psig.
4. Body Material: Brass.
5. Size: Same as connected piping.
6. Inlet: Threaded.
7. Drain Outlet: Threaded and capped.
8. Branch Outlet: Threaded, for sprinkler.

D. Sprinkler Inspector's Test Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing Inc.
 - b. Triple R Specialty.
 - c. Tyco Fire & Building Products LP.
 - d. Victaulic Company.
 - e. Viking Corporation.
2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
3. Pressure Rating: 175-psig minimum.
4. Body Material: Cast- or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

E. Adjustable Drop Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aegis Technologies, Inc.
 - b. CECA, LLC.
 - c. Corcoran Piping System Co.
 - d. Merit Manufacturing
 - e. Tyco Fire & Building Products LP.
2. Standard: UL 1474.
3. Pressure Rating: 250-psig minimum.

4. Body Material: Steel pipe with EPDM-rubber O-ring seals.
5. Size: Same as connected piping.
6. Length: Adjustable.
7. Inlet and Outlet: Threaded.

F. Flexible Sprinkler Hose Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis of Design: Victaulic Company. Vic-Flex.
3. Upon approval of the engineer:
 - a. Victaulic
 - b. FlexHead Industries, Inc.
 - c. Gateway Tubing, Inc.
 - d. Tyco Fire & Building Products LP.
4. Standard: UL 1474.
5. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid with zinc plated steel Male threaded nipple or Victaulic FireLock IGS Groove Style 108 coupling for connection to branch-line piping.
6. Pressure Rating: UL listed for sprinkler services to 175-psig minimum and FM Approved to 200 psi.
7. Size: Same as connected piping, for sprinkler.
8. The drop shall include a UL approved Series AH1 with 3" bend radius; AH2 or AH2-CC braided hose with a bend radius to 2" to allow for proper installation in confined spaces.
9. Union joints shall be provided for ease of installation.
10. The flexible drop shall attach to the ceiling grid using a one-piece open gate Series AB1 or AB2 bracket. The bracket shall allow installation before the ceiling tile is in place.

G. Automatic Air Vents:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Potter Electric Signal Company – Model PAV
2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
3. Pressure Rating: 175-psig minimum.
4. Body Material: Brass.
5. Size: 1/2" NPT inlet with 1/2" outlet to drain.
6. Inlet and Outlet: Threaded.
7. Accessories: Ball valve supervisory switch Model RBVS

2.18 SPRINKLERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Basis of Design: Victaulic Company.
 2. Upon approval of the engineer:
 - a. Victaulic
 - b. Reliable Automatic Sprinkler Co., Inc. (The).

- c. Tyco Fire & Building Products LP.
 - d. Viking Corporation.
- B. Sprinklers shall be glass bulb type, with hex shaped wrench boss integrally cast into the sprinkler body to reduce the risk of damage during installation. (Wrenches shall be provided by the sprinkler manufacturer that directly engage the cast wrench boss.)
- C. Basis of Design: Victaulic.
- D. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
- E. Pressure Rating for Residential Sprinklers: 175-psig maximum.
- F. Pressure Rating for Automatic Sprinklers: 175-psig minimum.
- G. Automatic Sprinklers with Heat-Responsive Element:
 - 1. Nonresidential Applications: UL 199.
 - 2. Residential Applications: UL 1626.
 - 3. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
- H. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed flush, and recessed-type sprinklers are specified with sprinklers.
 - 1. Ceiling Mounting: Chrome-plated steel, two piece, with 1-inch vertical adjustment.
 - 2. Sidewall Mounting: Chrome-plated steel, one piece, flat.
- I. Sprinkler Guards:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Reliable Automatic Sprinkler Co., Inc. (The).
 - b. Tyco Fire & Building Products LP.
 - c. Victaulic Company.
 - d. Viking Corporation.
 - 2. Standard: UL 199.
 - 3. Type: Wire cage with fastening device for attaching to sprinkler.
- J. Escutcheons and guards shall be listed and supplied for use with the sprinkler by the sprinkler manufacturer.

2.19 ALARM DEVICES

- A. Alarm-device types shall match piping and equipment connections.
- B. Electrically Operated Alarm Bell:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Tyco Fire & Building Products LP.
 - b. Notifier.
 - c. Potter Electric Signal Company, LLC.
2. Standard: UL 464.
3. Type: Vibrating, metal alarm bell.
4. Size: 6-inch minimum- diameter.
5. Finish: Red-enamel factory finish, suitable for outdoor use.
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Water-Flow Indicators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ADT Security Services, Inc.
 - b. McDonnell & Miller.
 - c. Potter Electric Signal Company, LLC.
 - d. Tyco Fire & Building Products LP.
 - e. Viking Corporation.
 - f. Watts; a Watts Water Technologies company.
2. Standard: UL 346.
3. Water-Flow Detector: Electrically supervised.
4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
5. Type: Paddle operated.
6. Pressure Rating: 250 psig.
7. Design Installation: Horizontal or vertical.

D. Pressure Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Barksdale, Inc.
 - b. Detroit Switch, Inc.
 - c. Potter Electric Signal Company, LLC.
 - d. Tyco Fire & Building Products LP.
 - e. United Electric Controls Co.
 - f. Viking Corporation.
2. Standard: UL 346.
3. Type: Electrically supervised water-flow switch with retard feature.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design Operation: Rising pressure signals water flow.

E. Valve Supervisory Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Fire-Lite Alarms, Inc.; a Honeywell International company.
 - b. Kennedy Valve Company; a division of McWane, Inc.
 - c. Potter Electric Signal Company, LLC.
 - d. Tyco Fire & Building Products LP.
2. Standard: UL 346.
 3. Type: Electrically supervised.
 4. Components: Single-pole, double-throw switch with normally closed contacts.
 5. Design: Signals that controlled valve is in other than fully open position.
 6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Indicator-Post Supervisory Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Potter Electric Signal Company, LLC.
 - b. Tyco Fire & Building Products LP.
2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled indicator-post valve is in other than fully open position.

2.20 PRESSURE GAUGES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AGF Manufacturing Inc.
 2. AMETEK, Inc.
 3. Ashcroft Inc.
 4. Brecco Corporation.
 5. WIKA Instrument Corporation.
 6. Viking Corporation.
 7. Tyco Fire & Building Products LP.
- B. Standard: UL 393.
- C. Dial Size: 3-1/2- to 4-1/2-inch diameter.
- D. Pressure Gage Range: 0 to 300 psig.
- E. Label: Include "WATER" label on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.

- B. Report test results promptly and in writing.

3.2 SERVICE-ENTRANCE PIPING

- A. Connect sprinkler piping to water-service piping for service entrance to building.
- B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-service piping.
- C. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

3.3 PIPING INSTALLATION

- A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated on approved working plans.
 - 1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
 - 2. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.
- B. Piping Standard: Comply with NFPA 13 requirements for installation of sprinkler piping.
- C. Install seismic restraints on piping. Comply with NFPA 13 requirements for seismic-restraint device materials and installation.
- D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
- E. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.
- H. Install sprinkler piping with drains for complete system drainage.
- I. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.
- J. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.
- K. Install alarm devices in piping systems.
- L. Furnish and install air release valve(s) at the high point(s) on the fire sprinkler system piping to assure evacuation of air from the system during and after filling. The automatic air release valve shall consist of a 40 mesh "Y" type strainer connected to an automatic air vent valve. The output of the air vent valve shall be a 1/2" NPT male connection which allows a drain attachment for safely draining inadvertent discharge. Install drainpipe to appropriate location. The air vent assembly

shall be field replaceable without disabling the sprinkler system by the installation of a ½" ball valve installed before the Y strainer for isolation purposes. The automatic air release valve shall be mounted in a vertical position and shall require a minimum of 8 " of clearance above the fire sprinkler main or branch line piping.

- M. Install pressure gauges on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gauges with connection not less than NPS 1/4 and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gauges to permit removal and install where they are not subject to freezing.
- N. Pressurize and check sprinkler system piping and air-pressure maintenance devices.
- O. Fill sprinkler system piping with water.
- P. Install sleeves for piping penetrations of walls, ceilings, and floors.
- Q. Install sleeve seals for piping penetrations of concrete walls and slabs.
- R. Install escutcheons for piping penetrations of walls, ceilings, and floors.
- S. Install drain valves on standpipes. Extend drain piping to outside of building.
- T. Install alarm devices in piping systems.
- U. Install hangers and supports for standpipe system piping according to NFPA 14. Comply with requirements in NFPA 13 for hanger materials.
- V. Install pressure gauges on riser or feed main and at top of each standpipe. Include pressure gauges with connection not less than NPS 1/4 and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gauges to permit removal and install where they are not subject to freezing.
- W. Fill wet-type standpipe system piping with water.

3.4 HANGERS

- A. All hangers and supports shall be in accordance with NFPA.
- B. All hangers shall be suspended directly from beams and the top chord of joists. Hangers shall not be suspended from the bottom chord of joists, from standard gauge metal decking, or from composite metal/concrete decking. Hanging from all other items, such as structural metal decking, shall require the approval of the Architect and shall be completed in accordance with details included on Structural Drawings.
- C. Suspend piping and equipment with all necessary hangers and supports required for a safe and workmanlike installation. Ensure that pipes are free to expand and contract and are graded properly, and that each hanger is adjusted to take its full share of the weight.
- D. Suspend hanger rods directly from the structure. Do not suspend from pipes, ducts, equipment, metal work, or ceilings. Where beam clamps are utilized, they shall be used with retaining straps.
- E. Supply and install auxiliary structural steel angles, channels and beams where piping and equipment must be suspended between joists or beams.

- F. Hangers shall be spaced to ensure that structural steel members are not overstressed. In no case shall pipe hangers be further apart than indicated in the tables. Where appropriate, include details on the "Fire Protection Working Drawings" of hangers as well as showing locations and magnitude of piping and equipment loads on the structure.
- G. Support of the sprinkler systems at the skylights and cupolas shall be subject to the approval of the skylight manufacturer. Close coordination and attention shall be given to the type of and placement of hangers at these locations to ensure that skylight structure is not overstressed.
- H. The use of trapeze-type hangers for support of piping shall be subject to prior acceptance. Where permitted, fabricate from angle or channel frames and space hangers to suit the smallest pipe size.
- I. Do not use hooks, chains, or straps to support equipment and materials.
- J. For precast concrete work, if inserts cannot be cast into members, pass hanger rods between the members and weld to steel plates resting on the upper surface of the precast interval. To prevent raising of the hanger rod, apply a lock nut and 2 inches minimum diameter slot washer tight against the upper surface of the precast material.
- K. Ensure that copper materials are completely isolated from ferrous materials. Use either plastic coated hangers and clamps, or use inserts between copper piping and ferrous materials, and between copper piping and copper coated ferrous materials.
- L. All hangers shall have provision for adjustment. Hangers and rods in equipment rooms shall have a prime coat of rust inhibitive paint or cadmium coating.
- M. Use round steel threaded rods, which shall conform to ASTM Spec. A-36, diameters as referenced by NFPA.

3.5 HOSE-CONNECTION INSTALLATION

- A. Install hose connections adjacent to standpipes.
- B. Install freestanding hose connections for access and minimum passage restriction.
- C. Install wall-mounted-type hose connections in cabinets. Include pipe escutcheons, with finish matching valves, inside cabinet where water-supply piping penetrates cabinet. Install valves at angle required for connection of fire hose.
- D. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- E. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. Escutcheons for New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
- F. Install floor plates for piping penetrations of equipment-room floors.
- G. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor-plate type.
2. Existing Piping: Split-casting, floor-plate type.

3.6 JOINT CONSTRUCTION

- A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
- B. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.
- G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 1. Apply appropriate tape or thread compound to external pipe threads.
 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- H. Steel-Piping, Pressure-Sealed Joints: Join lightwall steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.
- I. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
 1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.
- J. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints. Install in accordance with the manufacturer's latest published installation instructions. Pipe ends shall be clean and free from indentations, projections and roll marks in the area from pipe end to (and including) groove. Gasket shall be manufactured by the coupling manufacturer and verified as suitable for the intended service. A factory trained representative (direct employee) of the coupling manufacturer shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and product installation. The representative shall periodically visit the job site and review installation to ensure best practices in grooved joint installation are being followed. Contractor shall remove and replace any improperly installed products.
- K. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Braze Joints" Chapter.

- L. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.7 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Examine grooved ends for form and cleanliness. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove.
- F. Do not attempt to repair defective valves; replace with new valves.

3.8 GENERAL REQUIREMENTS FOR VALVE INSTALLATION

- A. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
- B. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.
- C. Install valves having threaded connections with unions at each piece of equipment arranged to allow easy access, service, maintenance, and equipment removal without system shutdown. Provide separate support where necessary.
- D. Install valves in horizontal piping with stem at or above the pipe center.
- E. Install valves in position to allow full stem movement.
- F. Install valve tags. Comply with requirements in Section 210553 "Identification for Fire-Suppression Piping and Equipment" for valve tags and schedules and signs on surfaces concealing valves; and the NFPA standard applying to the piping system in which valves are installed. Install permanent identification signs indicating the portion of system controlled by each valve.
- G. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections.
- H. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

3.9 VALVE AND SPECIALTIES INSTALLATION

- A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.
- B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
- C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.
- D. Specialty Valves:
 - 1. Install valves in vertical position for proper direction of flow, in main supply to system.
 - 2. Install alarm valves with bypass check valve and retarding chamber drain-line connection.

3.10 SPRINKLER INSTALLATION

- A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels.
- B. Install sprinklers into flexible, sprinkler hose fittings, and install hose into bracket on ceiling grid.
- C. Do not install sprinklers that have been dropped, damaged, or show a visible loss of fluid. Never install sprinklers with cracked bulbs.
- D. Sprinkler bulb protector shall be removed by hand after installation. Do not use tools or any other device(s) to remove the protector that could damage the bulb in any way.

3.11 IDENTIFICATION

- A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.
- B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.12 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
 - 4. Energize circuits to electrical equipment and devices.
 - 5. Coordinate with fire-alarm tests. Operate as required.
 - 6. Coordinate with fire-pump tests. Operate as required.
 - 7. Verify that equipment hose threads are same as local fire department equipment.
- B. Sprinkler piping system will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.13 CLEANING

- A. Clean dirt and debris from sprinklers.
- B. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

3.14 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves and pressure-maintenance pumps.

3.15 PIPING SCHEDULE

- A. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends, cast-iron threaded fittings, and joints.
- B. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.
- C. Standard-pressure NPS 2 and smaller, shall be one of the following:
 - 1. Standard-weight schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 - 2. Standard-weight schedule 40, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - 3. Piping 2" may be standard weight schedule 40, black steel with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
- D. Standard-pressure, NPS 2-1/2 to NPS 8, shall be one of the following:
 - 1. Schedule 10 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.16 SPRINKLER SCHEDULE

- A. Use sprinkler types in subparagraphs below for the following applications:
 - 1. Rooms without Ceilings: Upright sprinklers.
 - 2. Rooms with Suspended Ceilings: Concealed sprinklers.
 - 3. Wall Mounting: Sidewall Concealed sprinklers.
 - 4. Spaces Subject to Freezing: Upright sprinklers.
- B. Provide sprinkler types in subparagraphs below with finishes indicated.
 - 1. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
 - 2. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
 - 3. Upright or Pendent Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION

SECTION 212933

CONTROLLERS FOR FIRE-PUMP DRIVERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Full-service, full-voltage controllers rated 600 V and less.
 - 2. Controllers for diesel-drive fire pumps.
 - 3. Controllers for pressure-maintenance pumps.

1.3 DEFINITIONS

- A. ATS: Automatic transfer switch(es).
- B. ECM: Electronic control module.
- C. MCCB: Molded-case circuit breaker.
- D. NO: Normally open.
- E. PID: Proportional integral derivative.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For each type of product indicated.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Show tabulations of the following:
 - a. Each installed unit's type and details.
 - b. Enclosure types and details for types other than NEMA 250, Type 2.
 - c. Factory-installed devices.
 - d. Nameplate legends.
 - e. Short-circuit current (withstand) rating of integrated unit.
 - f. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices.
 - g. Specified modifications.

4. Include diagrams for power, signal, alarm, control wiring, and pressure-sensing tubing.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Product Certificates: For each type of product indicated, from manufacturer.
- C. Source quality-control reports.
- D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of product indicated to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 1. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
 2. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor-based logic controls.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of an NRTL.
- B. Source Limitations: Obtain fire-pump controllers and all associated equipment from single source or producer.

1.8 FIELD CONDITIONS

- A. Environmental Limitations:
 1. Ambient Temperature Rating: Not less than 5 deg C and not exceeding 50 deg C unless otherwise indicated.
 2. Altitude Rating: Not exceeding 2010 m unless otherwise indicated.
- B. Interruption of Existing Electric Service: Notify Construction Manager no fewer than seven days in advance of proposed interruption of electric service and comply with NFPA 70E.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with NFPA 20 and NFPA 70.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 FULL-SERVICE CONTROLLERS FOR ELECTRIC DRIVEN FIRE PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Aquarius Fluid Products, Inc.
 - 2. ASCO Power Technologies, LP; a business of Emerson Network Power.
 - 3. Eaton.
 - 4. Hubbell Incorporated.
 - 5. Joslyn Clark Corporation.
 - 6. Master Control Systems, Inc.
 - 7. Metron Control Products div. Hubbell Industrial Controls.
 - 8. Tornatech.
- B. General Requirements for Full-Service Controllers:
 - 1. Comply with NFPA 20 and UL 218.
 - 2. Combined automatic and nonautomatic operation.
 - 3. Factory assembled, wired, and tested; continuous-duty rated and service entrance rated
- C. Method of Starting:
 - 1. Pressure-switch actuated.
 - a. Water-pressure-actuated switch and pressure transducer with independent high-and low-calibrated adjustments responsive to water pressure in fire-suppression piping.
 - b. System pressure recorder, electric ac driven, with spring backup.
 - c. Programmable minimum-run-time relay to prevent short cycling.
 - d. Programmable timer for weekly tests.
 - 2. Magnetic Controller: Wye-delta (open transition) type.
 - 3. Emergency Start: Mechanically operated start handle that closes and retains the motor RUN contactor independent of all electric or pressure actuators.
- D. Method of Stopping: Automatic and nonautomatic shutdown after automatic starting.
- E. Capacity: Rated for fire-pump-driver horsepower and short-circuit-current (withstand) rating equal to or greater than short-circuit current available at controller location.
- F. Method of Isolation and Overcurrent Protection: Interlocked isolating switch and nonthermal MCCB; with a common, externally mounted operating handle, and providing locked-rotor protection.
- G. Door-Mounted Operator Interface and Controls:
 - 1. Monitor, display, and control the devices, alarms, functions, and operations listed in NFPA 20 as required for drivers and controller types used.
 - 2. Method of Control and Indication:
 - a. Microprocessor-based logic controller, with multiline digital readout.
 - b. Membrane keypad.
 - c. LED alarm and status indicating lights.

3. Local and Remote Alarm and Status Indications:
 - a. Controller power on.
 - b. Motor running condition.
 - c. Loss-of-line power.
 - d. Line-power phase reversal.
 - e. Line-power single-phase condition.
 4. Audible alarm, with silence push button.
 5. Nonautomatic START and STOP push buttons or switches.
- H. Optional Features:
1. Extra Output Contacts:
 - a. One NO contact(s) for motor running condition.
 - b. One set(s) of contacts for loss-of-line power.
 2. Local alarm bell.
 3. Door-mounted thermal or impact printer for alarm and status logs.
 4. Operator Interface Communications Ports: USB, Ethernet, and RS485.
- I. ATS:
1. Complies with NFPA 20, UL 218, and UL 1008.
 2. Integral with controller as a listed combination fire-pump controller and power transfer switch.
 3. Automatically transfers fire-pump controller from normal power supply to alternate power supply in event of power failure.
 4. Allows manual transfer from one source to the other.
 5. Alternate-Source Isolating and Disconnecting Means: Integral molded-case switch, with an externally mounted operating handle.
 6. Alternate-Source Isolating and Disconnecting Means: Mechanically interlocked isolation switch and circuit breaker rated at a minimum of 115 percent of rated motor full-load current, with an externally mounted operating handle; circuit breaker shall be provided with nonthermal sensing, instantaneous-only short-circuit overcurrent protection to comply with available fault currents.
 7. Local and Remote Alarm and Status Indications:
 - a. Normal source available.
 - b. Alternate source available.
 - c. In normal position.
 - d. In alternate position.
 - e. Isolating means open.
 8. Audible alarm, with silence push button.
 9. Nonautomatic (manual, nonelectric) means of transfer.
 10. Engine test push button.
 11. Start generator output contacts.
 12. Timer for weekly generator tests.

2.3 ENCLOSURES

- A. Fire-Pump Controllers and ATS, NEMA 250, to comply with environmental conditions at installed locations and NFPA 20.
 - 1. Indoor, Dry and Clean Locations: Type 1 (IEC IP10).
- B. Enclosure Color: Manufacturer's standard "fire-pump-controller red".
- C. Nameplates: Comply with NFPA 20; complete with capacity, characteristics, approvals, listings, and other pertinent data.
- D. Optional Features:
 - 1. Floor stands, 305 mm high, for floor-mounted controllers.

2.4 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect fire-pump controllers according to requirements in NFPA 20 and UL 218.
 - 1. Verification of Performance: Rate controllers according to operation of functions and features specified.
- B. Fire-pump controllers will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and surfaces to receive equipment, with Installer present, for compliance with requirements and other conditions affecting performance.
- B. Examine equipment before installation. Reject equipment that is wet or damaged by moisture or mold.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONTROLLER INSTALLATION

- A. Coordinate installation of controllers with other construction including conduit, piping, fire-pump equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels. Ensure that controllers are within sight of fire-pump drivers.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided.
- C. Install controllers within sight of their respective drivers.
- D. Connect controllers to their dedicated pressure-sensing lines.

- E. Floor-Mounting Controllers: Install controllers on concrete base(s), using floor stands high enough so that the bottom of enclosure cabinet is not less than 305 mm above finished floor.
 - 1. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
 - 2. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 3. Install anchor bolts to elevations required for proper attachment to supported equipment.
- F. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- G. Comply with NEMA ICS 15.

3.3 POWER WIRING INSTALLATION

- A. Install power wiring between controllers and their services or sources, and between controllers and their drivers. Comply with requirements in NFPA 20, NFPA 70, and Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 CONTROL AND ALARM WIRING INSTALLATION

- A. Install wiring between controllers and remote devices and facility's central monitoring system. Comply with requirements in NFPA 20 and NFPA 70.
- B. Install wiring between controllers and the building's fire-alarm system.
- C. Bundle, train, and support wiring in enclosures.
- D. Connect remote manual and automatic activation devices where applicable.

3.5 IDENTIFICATION

- A. Comply with requirements in NFPA 20 for marking fire-pump controllers.
- B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification in NFPA 20.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
- D. Acceptance Testing Preparation:
 - 1. Inspect and Test Each Component:
 - a. Inspect wiring, components, connections, and equipment installations. Test and adjust components and equipment.

- b. Test insulation resistance for each element, component, connecting supply, feeder, and control circuits.
 - c. Test continuity of each circuit.
 - 2. Verify and Test Each Electric-Drive Controller:
 - a. Verify that voltages at controller locations are within plus 10 or minus 1 percent of motor nameplate rated voltages, with motors off. If outside this range for any motor, notify Construction Manager before starting the motor(s).
 - b. Test each motor for proper phase rotation.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Field Acceptance Tests:
- 1. Do not begin field acceptance testing until suction piping has been flushed and hydrostatically tested and the certificate for flushing and testing has been submitted to Construction Manager and authorities having jurisdiction.
 - 2. Prior to starting, notify authorities having jurisdiction of the time and place of the acceptance testing.
 - 3. Engage manufacturer's factory-authorized service representative to be present during the testing.
 - 4. Perform field acceptance tests as outlined in NFPA 20.
- F. Controllers will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports.
- 3.7 STARTUP SERVICE
- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
- 3.8 ADJUSTING
- A. Adjust controllers to function smoothly and as recommended by manufacturer.
 - B. Set field-adjustable switches, auxiliary relays, time-delay relays, and timers.
 - C. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.
 - D. Set field-adjustable pressure switches.
- 3.9 PROTECTION
- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.

- B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.10 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controllers, and to use and reprogram microprocessor-based controls within this equipment.

END OF SECTION

SECTION 213113

FIRE PROTECTION FIRE PUMP SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Horizontally mounted, single-stage, split-case with electric motor drive fire pumps.
 - 2. Fire-pump accessories and specialties.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For fire pumps, motor drivers, and fire-pump accessories and specialties.
 - 1. Include plans, elevations, sections, and mounting and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of fire pump, from manufacturer.
- B. Source quality-control reports.
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fire pumps to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 FIRE PUMP

- A. The fire pump shall be a Peerless Pump model 6AE14A, horizontal split case base mounted, bronze fitted, single stage, double suction, centrifugal pump as supplied by Gustavo Preston Co, 978-250-3333.

- B. Pump shall be designed to deliver 1000 GPM when producing a differential pressure of 60 PSI.
- C. The pump casing shall be cast iron with 8" 125-pound ANSI rated suction and 6", 125 pound ANSI rated discharge flanges machined to American National Standards Institute (ANSI) dimensions.
- D. The driver shall be a 50 Hp / 1800 RPM horizontal, foot mounted, open drip-proof, ball bearing type, AC, induction, squirrel cage motor: wound for 460 volts, 3 phase, 60 Hertz. The motor shall be of such capacity that 115% of the full-load ampere rating shall not be exceeded at any condition of pump load. Locked rotor current shall not exceed the values specified in NFPA Pamphlet No. 20.
- E. Pump and motor shall be mounted on a common fabricated steel baseplate. The pump and driver shall be connected by a UL Listed coupling for fire service. Pump and motor shall be checked for alignment after the pump base has been installed, and after the base has been grouted in place, final alignment shall be laser alignment by pump manufacturer's representation, provide before and after alignment reports for installation and operations manuals. The pump manufacturer's representative company shall employ its own service group with 24/7 service capabilities.
- F. Casings shall be of cast iron having a minimum tensile strength of 35,000 P.S.I. Bearing housing supports, and suction and discharge flanges shall be integrally cast with the lower half of the casing. Removal of the upper half of the casing must allow the rotating element to be removed without disconnecting the suction and discharge flanges. Casings shall have integrally cast bearing housings, bolt-on bearing housings shall not be considered equal. Impellers shall be of the enclosed type and shall be of vacuum cast bronze. Impellers shall be dynamically balanced, keyed to the shaft, and held in place with threaded SS shaft sleeves.
- G. The pump shaft shall be made of SAE 1045 steel or equal, accurately machined to give a true running rotating element. Shaft shall be protected by 300 series stainless sleeves, key locked and threaded so that the sleeves tighten with the rotation of the shaft. An O-Ring shall seal between the impeller hub and the shaft sleeve to protect the pump shaft.
- H. Pump shall be equipped with renewable bronze casing rings so designed that the hydraulic pressure seats them against a shoulder in the pump case around the full periphery of the wearing ring. The wearing rings will be locked by doweling to prevent rotation. The rotating element uses heavy-duty grease lubricated ball bearings and shall be equipped with water slingers. Bearing housings shall be so designed to flush lubricant through the bearing.
- I. All pumps where the suction pressure is expected to average 40 P.S.I. or below, shall be provided with a lantern ring connected to the pressure side of the pump by a tee atop the pump casing. Stuffing boxes shall be equipped with split, cast stainless steel packing glands designed for easy removal for packing inspection and maintenance.
- J. The fire pump unit shall include the following accessories, as required by NFPA 20 standards:
 - 1. Liquid filled Suction pressure gauge
 - 2. Liquid filled Discharge pressure gauge
 - 3. 1/2" Automatic air release valve rated 300 PSI
 - 4. 3/4" Cla-Val casing relief valve rated 20-300 PSI
 - 5. Eccentric Suction Reducer
 - 6. Concentric Discharge Reducer
 - 7. Hose valve head, with angle hose valves, caps and chains
 - 8. Flowmeter

2.2 JOCKEY PUMP

- A. Contractor shall furnish and install a vertical multistage Grundfos Jockey Pump model CR1-8 with a rated capacity of 10 US GPM against a total head of 74 PSI.
- B. The pump shall be coupled to a motor rated 1 Hp 460 Volt, 60 Hz 3 Phase, Totally Enclosed Fan Cooled enclosure which is built to NEMA standards.
- C. The pump shall have stainless steel diffusers and cast-iron adapter with registered fits to maintain axial alignment, stainless steel enclosed impellers, PTFE neck ring, steel shaft coupling, stainless steel shaft. The impellers shall conform to shaft shape to prevent damage due to reverse rotation and to maintain proper interstage lateral setting.
- D. Pump shall be designed for and equipped with a mechanical seal type stuffing box. A vent tap shall be provided for mechanical seal units to relieve entrapped air. Pump shall be provided with cast iron base with drain plug.
- E. Where jockey pump churn pressures may exceed system design pressures, a casing relief valve shall be installed before the jockey check valve.

2.3 PERFORMANCE REQUIREMENTS

- A. NFPA Compliance: Comply with NFPA 20.
- B. Pump Equipment, Accessory, and Specialty Pressure Rating: 175 psig minimum unless higher pressure rating is indicated.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.4 GENERAL REQUIREMENTS FOR CENTRIFUGAL FIRE PUMPS

- A. Description: Factory-assembled and -tested fire-pump and driver unit.
- B. Base: Fabricated and attached to fire-pump and driver unit, with reinforcement to resist movement of pump during seismic events when base is anchored to building substrate.
- C. Finish: Red paint applied to factory-assembled and -tested unit before shipping.

2.5 HORIZONTALLY MOUNTED, SINGLE-STAGE, SPLIT-CASE FIRE PUMPS WITH ELECTRIC MOTOR DRIVE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. A-C Fire Pump; a Xylem brand.
 - 2. Corcoran Piping System Co.
 - 3. PACO Pumps; Grundfos Pumps Corporation, USA.
 - 4. Patterson Pump Company; a Gorman-Rupp company.
 - 5. Peerless Pump Company.
 - 6. Pentair Pump Group.
 - 7. S.A. Armstrong Limited.
- B. Pump:

1. Standard: UL 448, for split-case pumps for fire service.
 2. Casing: Axially split case, cast iron, with ASME B16.1 pipe-flange connections.
 3. Impeller: Double suction, cast bronze, statically and dynamically balanced, and keyed to shaft.
 4. Wear Rings: Replaceable bronze.
 5. Shaft and Sleeve: Alloy steel shaft with bronze sleeve.
 - a. Shaft Bearings: Grease-lubricated ball bearings in cast-iron housing.
 - b. Seals: Stuffing box with minimum of four rings of graphite-impregnated braided yarn and bronze packing gland.
 6. Mounting: Pump and driver shafts are horizontal, with pump and driver on same base.
- C. Coupling: Flexible and capable of absorbing torsional vibration and shaft misalignment. Include metal coupling guard.
- D. Driver:
1. Standard: UL 1004A.
 2. Type: Electric motor; NEMA MG 1, polyphase Design B.
- E. Capacities and Characteristics:
1. Reference fire pump specification schedule on drawings.

2.5 FIRE-PUMP ACCESSORIES AND SPECIALTIES

- A. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump casing.
- B. Circulation Relief Valves: UL 1478, brass, spring loaded; for installation in pump discharge piping.
- C. Relief Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BERMAD Control Valves.
 - b. CLA-VAL Automatic Control Valves.
 - c. Kunkle Valve.
 - d. OCV Control Valves.
 - e. Watts; a Watts Water Technologies company.
 - f. Zurn Industries, LLC.
 2. Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.
- D. Inlet Fitting: Eccentric tapered reducer at pump suction inlet.
- E. Outlet Fitting: Concentric tapered reducer at pump discharge outlet.
- F. Discharge Cone: Closed or open type.
- G. Hose Valve Manifold Assembly:

1. Standard: Comply with requirements in NFPA 20.
2. Header Pipe: ASTM A 53/A 53M, Schedule 40, galvanized steel, with ends threaded according to ASME B1.20.1.
3. Header Pipe Fittings: ASME B16.4, galvanized cast-iron threaded fittings.
4. Automatic Drain Valve: UL 1726.
5. Manifold:
 - a. Test Connections: Comply with UL 405; however, provide outlets without clappers instead of inlets.
 - b. Body: Flush type, brass, or ductile iron, with number of outlets required by NFPA 20.
 - c. Nipples: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe, with ends threaded according to ASME B1.20.1.
 - d. Adapters and Caps with Chain: Brass or bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
 - e. Escutcheon Plate: Brass or bronze; rectangular.
 - f. Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
 - g. Exposed Parts Finish: chrome plated.
 - h. Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

2.7 GROUT

- A. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink and recommended for interior and exterior applications.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.8 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."
 1. Verification of Performance: Rate fire pumps according to UL 448.
- B. Fire pumps will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine equipment bases and anchorage provisions, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of fire pumps.

- B. Examine roughing-in for fire-suppression piping systems to verify actual locations of piping connections before fire-pump installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.
- B. Equipment Mounting:
 - 1. Install fire pumps on cast-in-place concrete equipment bases.
 - 2. Mount fuel tank at the required elevation to meet pump manufacturer's fuel inlet requirements.
- C. Install fire-pump suction and discharge piping equal to or larger than sizes required by NFPA 20.
- D. Support piping and pumps separately, so weight of piping does not rest on pumps.
- E. Install valves that are same size as connecting piping.
- F. Install pressure gauges on fire-pump suction and discharge flange pressure-gauge tapings.
- G. Install piping hangers and supports, anchors, valves, gauges, and equipment supports according to NFPA 20.
- H. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.
- I. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

3.3 ALIGNMENT

- A. Align split-case pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.
- B. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.
- C. Align piping connections.
- D. Align pump and driver shafts for angular and parallel alignment according to tolerances specified by manufacturer.

3.4 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to pumps and equipment to allow service and maintenance.

- C. Connect relief-valve discharge to drainage piping or point of discharge.
- D. Connect fire pumps to their controllers.

3.5 IDENTIFICATION

- A. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.

3.6 FIELD QUALITY CONTROL

- A. Test each fire pump with its controller as a unit. Comply with requirements for electric-motor-driver fire-pump controllers specified in Section 212933 "Controllers for Fire-Pump Drivers."
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
 - 1. After installing components, assemblies, and equipment, including controller, test for compliance with requirements.
 - 2. Test according to NFPA 20 for acceptance and performance testing.
 - 3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.
- F. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to Owner.

3.7 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire pumps.

END OF SECTION

SECTION 220000

GENERAL REQUIREMENTS FOR PLUMBING

PART 1 - GENERAL

1.0 FILING OF TRADE BIDS

- A. Trade bids shall be submitted in accordance with the provisions of Massachusetts General Laws (Ter. Ed.), Chapter 149, SECTION 44A TO 44L, inclusive, as amended. The time and place for submission of trade bids shall be as set forth under INSTRUCTIONS TO BIDDERS.
- A. Each trade bid filed with the Awarding Authority shall be accompanied by a BID BOND, CASH or CERTIFIED CHECK, or a TREASURER'S CHECK or CASHIER'S CHECK issued by a responsible bank or trust company, payable to the Town of Wakefield, the amount stipulated in the INSTRUCTIONS TO BIDDERS. A trade bid accompanied by any other form of bid deposit than those specified will be rejected.
- B. Each trade bid submitted for the work under the Section, shall be on a form furnished by the Awarding Authority, reference SECTION 44F of Chapter 149 of the General Laws, as amended.
- C. Work to be done under this Section is shown on the Drawings: P0-0-1, P1-0-0A, P1-0-0B, P1-0-0C, P1-0-0D, P1-1-0C, P1-1-0D, P1-1-1A, P1-1-1AB, P1-1-1B, P1-1-1C, P1-1-1D, P1-1-2A, P1-1-2B, P1-1-2C, P1-1-2D, P1-1-3A, P1-1-3B, P1-1-3C, P1-1-3D, P1-1-4A, P1-1-4B, P1-1-4C, P1-1-4D, P1-2-1A, P1-2-1B, P1-2-1C, P1-2-1D, P2-0-0A, P2-1-1A, P3-0-1, P4-0-1, P5-0-1, P5-0-2, PC-1-1, PL-1-1, PM-1-1.
- E. The listing of the Contract Drawings above shall not limit responsibility to determine the full extent of work of this Section as required by all Contract Drawings noted on the Contract Drawings-Title Sheet Drawing List, the Project Manual, and Addenda.
- F. Refer and comply with General Instructions prepared by the CM-R.
- G. Work to be done under this SECTION 220000 shall refer to and include the following specification SECTIONS:

22 00 00	GENERAL REQUIREMENTS FOR PLUMBING
22 00 05	COORDINATION DWG REQ PLUMBING
22 05 13	COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT
22 05 17	SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING
22 05 18	ESCUTCHEONS FOR PLUMBING PIPING
22 05 19	METERS AND GAUGES FOR PLUMBING PIPING
22 05 23	VALVES AND SPECIALTIES FOR PLUMBING PIPING
22 05 29	HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT
22 05 33	HEAT TRACING FOR PLUMBING PIPING
22 05 48.13	VIBRATION CONTROLS FOR PLUMBING PIPING AND EQUIPMENT
22 05 53	IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT
22 07 19	PLUMBING PIPING INSULATION
22 11 16	DOMESTIC WATER PIPING
22 11 23	NATURAL GAS PIPING
22 11 23.21	INLINE DOMESTIC WATER PUMPS
22 13 16	SANITARY WASTE AND VENT PIPING

GENERAL REQUIREMENTS FOR PLUMBING

22 14 13	STORM DRAINAGE PIPING
22 41 00	PLUMBING FIXTURES
22 45 00	EMERGENCY PLUMBING FIXTURES
22 61 13	COMPRESSED AIR PIPING
22 61 19	COMPRESSED AIR EQUIPMENT
22 62 13	VACUUM PIPING
22 62 19	VACUUM EQUIPMENT
22 66 00	CHEMICAL WASTE SYSTEMS

- H. The filed Trade Bidder for Work under this SECTION 220000 shall list in Paragraph E of the FORM FOR TRADE BID the names of each person or corporation whom he proposes to use to perform the following classes of work or part thereof and the bid price, therefore.

CLASS(ES) OF WORK

REFERENCE ARTICLE(S)

Insulation

Sub soil, foundation, and underslab drainage systems

- I. In any case in which the sub-bidder intends to perform with persons of their own staff the class of work listed above, they must nevertheless list their own name therefore under Paragraph E of the FORM FOR SUB-BID.

1.1 GENERAL PROVISIONS

- A. Attention is directed to the GENERAL CONDITIONS OF THE CONTRACT AND SUPPLEMENTARY GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications as fully as repeated herein.
- B. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.
- C. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.2 RELATED DOCUMENTS:

- A. Division 01 Specifications, General and Supplemental Requirements apply to this section with additions and modifications specified herein.
- B. Instructions to Bidders, Bidding Forms, Forms of Agreement between Owner and Contractor, Contract Award Date, Starting and Completion Dates, Conditions of the Contract, Insurance Requirements, and other Owner Requirements will be furnished separately by the Owner. These documents, as well as any addenda issued, shall form a part of these Specifications, and this Contractor shall consult them in detail for instructions pertaining to their work.
- C. Each trade contractor shall receive all drawings and specification sections issued as part of the overall bid package. All contractors are to receive, review, and coordinate all of their work as shown or referenced on the other trade documents. All work shown or referenced on the other trade documents shall be included as part of the overall project scope for that particular discipline and trade.

1.3 SCOPE OF WORK:

- A. These specifications and accompanying drawings are intended to cover the furnishing of all labor, material, and equipment and superintendence of the Plumbing System.
- B. It is the intent and purpose of these specifications and accompanying drawings to cover and include each item, all materials, machinery, apparatus, and labor necessary to properly install, equip, adjust, and put into perfect operation the respective portions of the installations specified and to so interconnect the various items or sections of the work as to form a complete and properly operating whole.
- C. Any equipment, apparatus, machinery, material and small items not mentioned in detail, and labor not hereinafter specifically mentioned, which may be found necessary to complete or perfect any portion of installation in a substantial manner, and in compliance with the requirements stated, implied or intended in these specifications shall be furnished without extra cost. This shall include all materials, devices or methods peculiar to the machinery, equipment, apparatus, or systems furnished and installed as part of the Plumbing work.
- D. The term "Furnish" shall mean to obtain and supply to the job site. The term "Install" shall generally mean to fix in position and connect for use. Where language indicates that one party or trade is to "install" and another is to "connect", the term "install" shall mean only to fix in position, and "connect" shall mean to make final connections to. The term "Provide" shall mean to furnish and install.

1.4 LAWS, REGULATIONS AND CODES:

- A. Perform all work in strict compliance with all laws, regulations, and/or codes applying, including all Federal, State, and local codes and any other authority having jurisdiction. Wherever drawings or specifications conflict with such regulations they shall be made to conform, and approval of the Design Professional obtained on such damages as may be involved.
- B. All plumbing work shall comply with the requirements of the National Standard, Massachusetts State Plumbing Code, latest revision, and local amendments to the code.

1.5 PERMITS, FEES, AND CERTIFICATES OF APPROVAL:

- A. Unless stated otherwise in General Conditions or Division 01, obtain, and pay for all permits, fees, and licenses required, including those of utilities and Agencies. Provide copies to Design Professional in the quantity requested.
- B. Perform all work in strict compliance with all law, regulations, and/or codes applying, including those of the National Fire Protection Association; the Massachusetts State Building Code; and other local codes and any other authority having jurisdiction. Wherever drawings or specifications conflict with such regulations they shall be made to conform, and approval of the Design Professional obtained on such changes as may be involved.
 - 1. "Fees" shall include connection charges construction costs, and other such charges by utility companies or service providers. Ascertain such charges during bidding period and include bid price.

1.6 REQUESTS FOR INFORMATION (RFI)

- A. Contractor is responsible for submitting Requests for Information (RFI)s when discrepancies arise, logical discrepancies are found on the contract documents, or clarification is necessary. All RFI's must be clearly written and submitted with a suggested solution. All RFI's regarding changes to the intent indicated on plans must be accompanied by sketches, explanation, site

pictures, and all other instruments necessary, to clearly convey the issue at hand and the suggested solution. The RFI process may only be utilized for legitimate purposes. RFI's may not be utilized to submit deviation or substitution requests, nor requesting confirmation of scope for items clearly defined on the contract documents, nor related to clarifications that should be resolved through the Contractor's coordination efforts. RFI's that do not comply will be summarily rejected and any delays caused as a result are the responsibility of the Contractor. In cases where the Contractor does not submit an RFI to clarify an issue and incorrectly proceeds, all work required to resolve such issues to be in compliance with the intent of the contract documents, as determined by the Engineer, shall be the Contractor's responsibility and at no additional cost to the project.

- B. The contractors are required to carefully examine all architectural and structural drawings for the building as well as all of the drawings for electrical trades, IT/AV/Security Trades, mechanical trades, plumbing trades and fire protection trades and be responsible for the proper fitting of all material and equipment into the building as planned and without interference with other piping, ductwork, conduit or equipment. Refer to the coordination drawing requirements. Proper judgment shall be exercised to secure best possible headroom, ceiling heights, door and window clearance, and space conditions throughout; to secure neat arrangement for piping, equipment, and conduit, and to overcome all local difficulties and interferences to best advantage. Approval for any and all changes to plans and specifications which may thus be incurred shall be obtained from the Design Professional before proceeding.

1.7 RECORD DRAWINGS:

- A. During construction keep an accurate record of all deviations of the work as shown on the drawings and that which is actually installed.
- B. Secure from the Design Professional, a complete set of prints of the Plumbing drawings and note changes thereon. Make a complete record in a neat and accurate manner, of all changes and revisions to original design which exist in completed work, in CAD file format.
- C. The cost of furnishing above CAD files and preparing these record drawings shall be borne by the Contractor. When all revisions showing the work as finally installed are made, the corrected white prints and CAD files on compact disc shall be submitted for review and approval by the Design Professional.
- D. Refer also to Division 01.
- E. Electronic files of plumbing work will be provided at the conclusion of the project for the purposes of preparing record drawings.

1.8 OPERATING INSTRUCTIONS

- A. Provide to the Owner three bound copies of complete written instruction on the operation, care, and maintenance of each piece of equipment and the installation as a whole. Include frequency of inspection, cleaning and adjusting and other attention as may be required in accordance with manufacturer's instructions. Material shall be manufacturer's brochures, catalog cuts, parts lists, wiring diagrams, etc. Also supply Owner with three complete sets of "No Exception Taken" shop drawings.
- B. Furnish qualified personnel to instruct the Owner's personnel in the maintenance and operation of all equipment and systems. Instructing personnel shall remain on the job continuously during working hours until such instruction is complete, but not less than 16 hours.

- C. A video recording in digital format (DVD) of the operator training session shall be made during this training period and the DVD submitted to the Owner with the operation and maintenance manuals.
- D. Refer also to Division 01.

1.9 CORRECTION OF WORK AFTER FINAL PAYMENT AND GUARANTEE:

- A. This article is supplementary to Guarantee Provisions of Division 01 and General Conditions.
- B. Final payment shall not relieve the Contractor of responsibility for faulty equipment, materials, and workmanship and unless otherwise specified they shall remedy any defects due thereto and pay for damage to other work resulting therefore, which shall appear within a period of one (1) year from the date of acceptance.
- C. Include guarantees by the respective equipment manufacturers which shall be subject to the terms and time limits defined under this Article of Specifications.
- D. Guarantees furnished by Sub-Contractor and/or equipment manufacturers shall be counter-signed by the related Prime Contractor for joint and/or individual responsibility for subject item.
- E. Manufacturers' equipment guarantees or warranties extending beyond the guarantee period described herein shall be transferred to the Owner along with the Contractor's guarantees.

1.10 QUALITY ASSURANCE

- A. Comply with the requirements of the following codes and/or standards:
 - 1. ASHRAE
 - 2. ANSI
 - 3. ASME
 - 4. ASTM
 - 5. UL
 - 6. NEMA
 - 7. AMCA
 - 8. NFPA
 - 9. ARI
 - 10. NEC
 - 11. IBC, latest version
- B. All packaged equipment shall be independently Third Party labeled as a system for its intended use by a Nationally Recognized Testing Laboratory (NRTL) in accordance with the OSHA Federal Regulations 29CFR1910.303 and .399, as well as NFPA Pamphlet #70 and National Electric Code (NEC), Article 90-7.

1.11 WARRANTIES

- A. Manufacturer's warranties on equipment provided under this contract shall be included in the operating and maintenance manuals.
- B. Warrantee period shall begin when the Owner receives beneficial use of the equipment. The installing contractor shall be responsible for protecting all equipment until the testing and balancing reports are accepted and commissioning reports are submitted.
- C. The period of "Owners Beneficial Use" shall begin when:
 - 1. Permanent or temporary certificate of occupancy is granted; or

2. Final Punchlist items are successfully completed; or
 3. Owner acknowledges benefits and risks of using the equipment to expedite completion of construction and grants permission for early use of plumbing systems.
- D. See specification section regarding restrictions on early use of plumbing equipment.

PART 2 - MATERIALS

2.1 MATERIALS AND EQUIPMENT:

- A. All installed materials and equipment shall be new and the best of their kind and shall conform to the grade, quality and standards specified herein.
- B. Unless otherwise specifically stated, all materials and equipment offered under these specifications shall be limited to products regularly produced and recommended by the manufacturer for the service intended. This material and equipment shall have capacities and ratings sufficient to amply meet the requirements of the project. The capacities and ratings shall be in accord with engineering data or other comprehensive literature made available to the public by the manufacturer and in effect at the time of opening of bids.
- C. Equipment shall be installed in accordance with manufacturer's instructions for type and quality of each piece of equipment used. These instructions shall be obtained from the manufacturer and shall be considered part of these specifications. Type, capacity, and application of equipment shall be guaranteed suitable to operate satisfactorily. No experimental material or equipment shall be permitted.

2.2 WORK DESCRIPTION:

- A. In general, the work shall consist of but not necessarily be limited to the following:
 1. Demolition, removal and replacement and relocation as noted herein.
 2. Complete sanitary system extending to base building connections.
 3. All soil, waste and vent piping and connections to all plumbing fixtures and other equipment requiring soil, waste and vent connections.
 4. Sump pumps and controls.
 5. All cold, hot, tempered and recirculating hot water piping and connections to all plumbing fixtures and other equipment requiring water connections.
 6. Domestic water heaters and recirculating pump and controls.
 7. All plumbing fixtures.
 8. Natural gas piping system.
 9. Laboratory gas systems.
 10. Insulation of all piping and other equipment as hereinafter specified.
 11. All miscellaneous pipe, fittings, drains, valves, hangers, anchors, sleeves, plates, flashings, and appurtenances necessary for a complete installation, leaving same ready for service. Unless stated otherwise all control wiring from electrical disconnect to valves, controls, and equipment, requiring same.
 12. Interior grease traps.
 13. Hose bibbs.
 14. Service water and waste connections to equipment provided under other sections.
 15. All supplemental steel for piping and equipment.
 16. Drilling for installation of inserts.
 17. System and equipment start-up.
 18. All hoisting, rigging, scaffolding and staging required for the plumbing work.
 19. Core drilling.
 20. Disinfection of domestic water system.

21. Pipe and valve marking and tags. (Painting as noted herein.)
22. All testing and adjusting of all systems.
23. Instruction and equipment manuals.
24. Instruction of Owner's representatives.

2.3 WORK INCLUDED:

- A. In addition to work described above under WORK DESCRIPTION. The work shall include but not necessarily be limited to the following:
 1. Provide removals, relocations, alternations and additions to existing Plumbing equipment and systems as shown on the Drawings. For removals and demolition refer to Article: REMOVAL OF EXISTING EQUIPMENT AND MATERIALS.
 2. Rigging of equipment and materials related to the Plumbing Work.

2.4 REMOVAL OF EXISTING EQUIPMENT AND MATERIALS:

- A. Remove all superfluous piping, fixtures, devices, controls, equipment, etc. Where removals are shown on Drawings, they are a general indication only, and may not necessarily indicate the full extent of the work.
- B. No existing equipment or material shall be reused without specific approval of the Owner's Representative.
- C. All equipment and material to be removed, and not desired by the Owner, shall be removed from the site by the Contractor.
- D. Any removed material which is desired by the Owner shall be moved to an on-site storage location by the Contractor.

2.5 CHASES AND OPENINGS:

- A. Provide information to the appropriate trades regarding size and location of all openings and chases as required for the installation of this Plumbing Work.

2.6 CUTTING AND PATCHING:

- A. All cutting and patching for installation of Plumbing work will be done by others.
- B. Provide all information required for such openings to the appropriate trade in a timely manner.
- C. Each contractor shall be responsible for sealing under-floor penetrations related to their trade. The testing and balancing contractor will measure the amount of air leakage and approximate location of leaks. Each contractor shall reseal and repair any leaks associated with their trade, occurring at locations determined during testing and balancing.

2.7 CONCRETE:

- A. All concrete required for work of the Plumbing Contract will be done by others.
- B. Provide to the appropriate trade all information required to properly complete concrete work.
- C. Concrete pads under equipment shall extend not less than four (4) inches beyond equipment base on all sides and shall be six inches above floor, in all cases not less than is indicated on the Drawings.

- D. Provide at the time of pouring concrete, all necessary anchor bolts. Anchor bolts shall be the hook type, or proper size and length to suit the equipment. Anchor bolts shall be set in pipe sleeves of approximately twice the bolt diameter and one half the embedded length of the of the bolt. Assume full responsibility for proper emplacement of bolts.
- E. Drop-in wedge anchor bolts or self-drilling anchors may be used in place of hook bolts. Minimum embedment in concrete of wedge anchor bolts shall be in accordance with manufacturer's instructions. Wedge anchor bolts shall be manufactured by Phillips Drill Co., or USM Corp. Self-drilling anchors shall be manufactured Phillips Drill Co.
- F. After equipment is set in place and bolted down, any space between equipment base and floor slab or foundation shall be completely filled with non-shrink grout equal to Masters Builders Co., Ltd. Embeco 153 grout.

2.8 STARTERS AND PILOT DEVICES (OR MOTOR CONTROLS):

- A. Combination magnetic motor starters shall be full voltage non-reversing with an adjustable instantaneous-trip circuit breaker (withstand rating 22,000 ampere rms symmetric minimum) (withstand rating 100,000 ampere rms symmetrical with current limiting module) or fused or unfused safety switch. Starters and protective devices shall be of sizes recommended by manufacturer for the motor to be controlled, but minimum size shall be NEMA size 1.
- B. Combination magnetic motor starters shall be full voltage non-reversing with a fused safety switch. Starters and protective devices shall be of sizes recommended by manufacturer for the motor to be controlled, but minimum size shall be NEMA size 1.
- C. Starters, which are not combination shall be similar, but without circuit breaker or switch.
- D. Refer to Division 15 and 16 Specifications for description of starter. Unless specified otherwise hereinafter, furnish non-combination starter with "hand-off-auto" selector switch, green "run" pilot light, and two (2) auxiliary contacts.
- E. Where starters or other devices are to be mounted outdoors enclosures shall be NEMA Type 4. All other enclosures, unless otherwise noted, shall be NEMA Type 1.
- F. All starter control circuits shall be 120V. Voltage shall be derived from starter line voltage via fused control transformer. Control transformers shall have sufficient capacity to properly operate any auxiliary equipment or devices. Provide transformers larger than manufacturer's standard size, as required by these conditions. Provide sufficient auxiliary contacts to properly interface other devices interlocked with the motor in question.
- G. Manual starters shall be toggle type, in surface or flush enclosure as required, and with pilot light. Provide overload heaters unless the motor to be controlled is thermally protected.
- H. Unless otherwise noted, overload heaters shall be melting-alloy non-automatic-reset type. Overload heaters shall not be selected based on average published motor currents but shall be selected based on the actual nameplate current of motors and service factor as installed.
- I. Push buttons, selector switches, pilot lights and similar pilot devices shall be NEMA 1 or NEMA 4, as noted in D, above. Pilot lights shall be neon or transformer type. Provide manufacturer's standard engraved nameplates which display the control function of the device (or for pilot lights, the action indicated).
- J. All starters and controls shall be Square D, General Electric, Westinghouse, Allen Bradley, Cutler-Hammer or ITE.

2.9 ELECTRICAL WORK AND MOTORS:

- A. All electrical work shall be done in strict accordance with the requirements of the National Electrical Code and the Electrical Specifications. All electrically operated equipment shall bear an Underwriter's Laboratories label where labeling service is available for that type of equipment.
- B. All motor frames shall be grounded. Electric power, control and grounding connections shall be factory wired to an outlet box or terminal strip enclosure on the apparatus for easy connection by the Electrical Contractor.
- C. All motors shall be designed and constructed in accordance with the latest standards of the IEEE and NEMA and shall meet UL requirements. Motors shall run quietly under all operating conditions.
- D. Single phase motors that are drip-proof or totally enclosed shall have Class A Insulation. Three phase motors 7-1/2 HP and larger shall have Class B Insulation. Three phase motors under 7-1/2 HP that are drip-proof or totally enclosed shall have Class A and Class B Insulation. These requirements are based on an ambient temperature of 40° C and service factor of 1.15 for open drip-proof motors; motors rated for 50°C ambient temperature shall have a factor of 1.0. Totally enclosed motors shall have a service factor of 1.0 in 40°C ambient temperature. Motors shall have the following efficiencies and power factor at full load. Efficiency for 10 to 50 HP shall be 90% and for 60 HP and above shall be 95%. Power factor for 10 HP and above shall be 95%. In lieu of these power factors, provide correction devices at individual motors to correct the above noted power factors. Contractor shall furnish documentation that demonstrates all power factor corrections meet or exceed the requirements noted above.
 - 1. All fractional horsepower single phase motors shall have an integral thermal overload circuit interrupting device with manual reset. If an integral overload is not available, install a motor rated toggle switch with thermal overload to the electrical contractor for installation by electrical contractor.
- E. Motors for use on equipment with variable speed drives shall be compatible for drive usage and be constructed per NEMA Standard MG-1 Part 31. Coordinate with variable speed drive manufacturers for motor requirements and drive output characteristics. All such motors shall have their cases bonded to the driven machinery frame with a ground strap. Motors shall be inverter duty and shall be equipped with shaft grounding rings.
- F. See Division 15 Specification for additional details.

2.10 WIRING FOR CONTROL SYSTEMS:

- A. This Article applies to wiring used for Plumbing Systems and similar types of control systems associated with work of Division 22.
- B. All wiring for control systems shall comply with Article 725 of the National Electrical Code, (NEC) or with Articles 760, 800, or 820 for control systems integrated into systems covered by those Articles.
 - 1. Particular attention shall be given to the requirements of the NEC for testing and labeling cables for use in plenums, risers, and other air-handling spaces.
- C. All wiring for control systems shall be of a type recommended by the system manufacturer and be installed in accordance with systems manufacturer's instructions.

- D. Cables must be in raceways when run through inaccessible ceilings, walls, or chases. Comply with Division 26 Specifications, for types of raceways required and their installation requirements. Cables run on surfaces within 8' of finished floor must be in raceways where exposed to physical damage.
 - 1. Where cables enter or leave raceways, provide insulated bushing or protective grommet.
- E. Cables may be run without raceways above accessible ceilings; in hollow stud partitions; and where properly supported in unfinished spaces without ceilings.
- F. Cables run without raceways shall be supported by bridle rings or similar hangers attached to the building structure at maximum 5'-0" centers. Hangers and/or cables shall not be supported from pipes, ducts, or similar equipment. Cables shall not be supported by lying on or across framing members or structural elements.
- G. Cables run without raceways shall be run parallel with, or perpendicular to, the lines of the building. Wiring shall be grouped neatly using plastic ties equal to "Ty-raps" at 30" maximum intervals.
- H. Wiring with or without raceways shall be run continuously between terminal boxes and outlets. All splices shall be made in NEMA 1 boxes with terminal strips or other acceptable connectors and permanent labels to identify each wire and cable, both entering and leaving the box.
- I. A separation of not less than 6" shall be maintained to heated pipelines.
- J. Cable run above hung ceilings used for environmental air shall be specifically listed and labeled for the use or shall be installed in a raceway.
- K. Wiring run without raceways through rated walls, floors and partitions shall be run in sleeves. All such sleeves shall be packed with fire-rated material.
- L. Wiring for different systems shall be grouped and run separately from other systems and shall be identified as to the system it serves.

2.11 SUBSTITUTIONS:

- A. Equipment may be shown or specified in several ways:
 - 1. Manufacturer and catalogue or model number with the words "no substitutions," "no equal," "(manufacturer) only," or words of similar respect. Contractor shall furnish the specified item.
 - 2. Several manufacturers and model numbers listed; or one manufacturer and model number, followed by "equals by (mfr A), (mfr B), (mfr C)," or words of similar respect.
 - a. If one of the manufacturers is listed on the drawings, that manufacturer shall be considered the basis of design. If none is so listed, the first manufacturer named in the Specification shall be considered the basis of design.
 - b. Where manufacturer's or supplier's name, style and catalog numbers are mentioned in the description of material and equipment in the specifications or on the drawings, it is to be understood that they are for the purpose of setting a standard.
 - c. If Contractor elects to furnish equipment other than the basis of design, they shall verify capacities, physical size, weight, electrical requirements, methods of connection to other parts of the system, and all other relevant data. Contractor shall be responsible for informing the Design Professional of all

changes required to other equipment, spaces, structure or systems in order to install the substituted equipment. They shall furnish all required shop drawings or sketches required for Design Professional to evaluate the required changes and shall be responsible for all costs associated with such changes, including costs of design or engineering, if such are necessary, and costs of other trades.

3. Where manufacturer's or supplier's names are listed in conjunction with the manufacturer or supplier that is basis of design, they are given to approve the firm name only. Equipment or material submitted by such firms must meet the detailed technical specifications written for the respective item. Contractor shall be responsible for verifying capacities, physical sizes, weights, electrical requirements, methods of connection to other parts of the system, etc. Contractor shall furnish all required shop drawings for equipment, and for its connection and installation.
 - B. If any substituted items are submitted after contracts have been awarded, and there is any question of equality of such items, samples may be required to be submitted both for the item specified and that to be substituted, or, further proof of equality may be required to the entire satisfaction of the Design Professional. In no case shall additional remuneration be allowed because of the rejection of a substitute.
 - C. When the equipment is relocated to a place other than that shown on the drawings, or when equipment other than that specified is used, the Contractor shall pay the extra cost of required revisions such as structural steel, concrete, electrical, piping, etc.
 - D. The Design Professional's costs to evaluate substitutions and to revise Drawings and Specifications because of substitutions will be paid by the Contractor.
- 2.12 SHOP DRAWINGS:
- A. Refer to Division 01.
 - B. Furnish shop drawings, catalog cuts, performance data and other required data to the Design Professional for approval for all material and equipment specified hereinafter. Sufficient data shall be submitted to show compliance with the requirements of the plans and specifications. All shop drawings submitted shall be first checked and corrected before submitting for approval. Approval for shop drawings by the Design Professional will not relieve the Contractor from responsibility for errors or omissions therein. All such errors or omissions must be made good by the Contractor irrespective of any approval by the Design Professional.
 - C. The following applies to all materials and equipment being submitted for this project. Refer to the individual specification sections for additional submittal requirements.
 - D. It is the responsibility of the manufacturer's representative and the installing contractor to thoroughly review all shop drawing equipment submittals and state in writing that the products meet or exceed the design specifications and design intent as indicated on the contract documents, prior to submitting them for review by the engineer.
 - E. The General Contractor or Construction Manager shall review and stamp all shop drawings noting their review process has taken place and that the shop drawings are in compliance with the design documents, prior to submitting the for review by the engineer. Any shop drawings found to not be in compliance shall be returned to the contractor stating such, with a copy of the statement (only) forwarded to the engineer.

- F. On submissions beyond the initial one, clearly identify all of the changes made from the initial submittal including those requested by the Design Professional. The Design Professional will review only those changes they requested and those identified by the Contractor.
- G. The Engineer will review three submissions (one original submission and up to two revised submissions) on any single component requested for review. If the contractor and/or vendor fail to comply with the drawings, specifications, and/or review comments and additional submissions are required, the cost for review and processing of those submissions will be borne by the contractor.
- H. The design documents are based and coordinated on the scheduled manufacturers. Any substitutions of products or materials (from those approved and listed in the specifications) must be thoroughly coordinated by the submitting contractor. This includes but is not limited to power, space, structural, control and performance requirements.
- I. Shop drawings required shall include, but not necessarily be limited to, the following:
1. Shop drawings, cuts and catalog information showing appearance, dimensions, performance, weight, etc., of all equipment, appurtenances, etc.
 2. Specifications Compliance Statement:
 - a. The manufacturer shall submit a point by point statement of compliance with the specifications.
 - b. The statement of compliance shall consist of a complete copy of the project specifications with a line by line compliance statement.
 - c. Where the proposed system complies fully, such shall be indicated by placing the word "comply" opposite the line or paragraph number.
 - d. Where the proposed system does not comply or accomplishes the stated function in a manner different from that described, a full description of the deviation shall be provided.
 - e. Where a full description of a deviation is not provided, it shall be assumed that the proposed system does not comply with the paragraph in question.
 - f. Submissions which do not include a point by point statement of compliance as specified shall be disqualified
 3. Schedules of all materials showing type and manufacturer.
 4. Wiring diagrams and schematics for equipment.
 5. All special equipment and systems.
 6. Any special constructions.
 7. Other shop drawings as may be requested.
- J. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristic, finishes for materials, and installation and startup instructions for each type of product indicated.
1. Each control device labeled with setting or adjustable range of control.
- K. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
1. Schematic flow diagrams showing all controlled equipment and control devices.
 2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
 3. Details of control panel faces, including controls, instruments, and labeling.
 4. Written description of sequence of operation.

5. Trunk cable schematic showing programmable control unit locations and trunk data conductors.
 6. Listing of connected data points, including connected control unit and input device.
 7. System graphics indicating monitored systems, data (connected and cSMSulated) point addresses, and operator notations.
 8. System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
- L. Shop Drawings shall be submitted and shall consist of a complete list of equipment and materials, including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions. Shop drawings shall also contain complete wiring, routing, schematic diagrams, tag number of devices, software descriptions, calculations, and any other details required to demonstrate that the system will function properly. Drawings shall show proposed layout and installation of all equipment and the relationship to other parts of the work.
- M. Shop Drawings shall be approved before any equipment is installed. Therefore, shop drawings must be submitted in time for review so that all installations can be completed per the project completion schedule. Ten working days shall be allowed for submittals to be reviewed.
- N. All drawings shall be reviewed after the final system checkout and updated or corrected to provide "as-built" drawings to show exact installation. All shop drawings will be acknowledged in writing before installation is started and again after the final checkout of the system. The system will not be considered complete until the "as-built" drawings have received their final approval. The Contractor shall deliver a complete set of "as-built" drawings.
- O. On submissions beyond the initial one, clearly identify changes made from the initial submittal other than those requested by the Design Professional. The Design Professional will review only those changes they requested and those identified by the Contractor.
- P. If the Contractor elects to proceed to install equipment for which approved Shop Drawings have not been received, they do so at their own risk; Design Professional is not obligated to accept such equipment or work, nor will Design Professional be liable for claimed costs or delays required by correction of such work.

Shop Drawing Review Comment Definitions

A> No Exception Taken:

The shop drawing or equipment submittal as submitted is approved without exception. No changes or corrections required. The materials, equipment or system submitted can be released for fabrication and construction. No Further Submission Required.

B> Make Corrections Noted:

The shop drawing or equipment submittal as submitted is not completely correct but is approved as noted. Make the corrections noted on the shop drawing or submittal. The materials, equipment or system submitted can be released for fabrication and construction once the corrections have been made. The submittal must be corrected and resubmitted for record unless noted by "E: Resubmit". See "E: Resubmit" definition below.

C> Submit Specified Item:

The shop drawing or equipment submittal as submitted is missing a component of the system that it represents or is not of the approved and specified manufacturers. Submit

the missing or incorrect item. The materials, equipment or system submitted cannot be released for fabrication and construction.

D> No Further Submission Required:

The shop drawing or equipment submittal as submitted is approved as noted. No changes or corrections required. The materials, equipment or system submitted can be released for fabrication and construction. No Further Submission Required.

E> Resubmit:

The shop drawing or equipment submittal as submitted is not approved. The shop drawing or equipment submittal needs significant corrections and does require another submission to verify that the comments and changes have been incorporated. Make the corrections noted on the shop drawing or submittal. The materials, equipment or system submitted cannot be released for fabrication and construction.

F> Rejected:

The shop drawing or equipment submitted is not as specified or a non-approved manufacturer or product and rejected.

G> Resubmit for Record Only:

Make the corrections noted on the shop drawing or submittal. The shop drawing or equipment submittal as submitted is approved with minor exception. Changes or corrections are required. The materials, equipment or system submitted can be released for fabrication and construction.

PART 3 - EXECUTION

3.1 VISIT TO SITE:

- A. Before submitting bid, visit the site of the work and be thoroughly familiarized with the conditions affecting the work. No extra payment will be allowed on account of extra work made necessary by failure to do so.

3.2 WORKMANSHIP:

- A. All work shall be installed in a first class, neat and workmanlike manner by mechanics skilled in the trade involved. All details of the installation shall be mechanically correct. Should the Design Professional direct removal, change, or installation of any equipment or systems not installed in a neat and workmanlike manner, such changes shall be made by the Plumbing Contractor at no expense to the Owner.
- B. Equipment shall be installed in strict accordance with manufacturer's instructions for type and capacity of each piece of equipment used. The Contractor shall obtain these instructions from the manufacturer and these instructions shall be considered part of these Specifications.
- C. Drawings and specifications have been prepared with best knowledge of conditions available at the time of design. If any obscurities or discrepancies exist, they shall be brought to the attention of the Design Professional before bids are submitted. If they are not discovered

before bids are submitted, the Design Professional shall be notified and shall render decision. This decision shall be final.

1. Drawings and Specifications are intended to be complementary; items described or shown in one but not the other are to be furnished as if fully shown on described in both locations.
- D. Drawings are generally indicative of the work to be installed, but do not indicate all bends, fittings, and specialties which may be required, or the exact locations of all piping and ductwork. Contractor shall investigate structure and finish conditions affecting their work and arrange their work; accordingly, furnishing such fittings as may be required to meet such conditions. Contractor is responsible for exercising proper judgment to arrange their work and materials so as to avoid interference with other trades.
 1. Riser diagrams and schematics generally indicate equipment to be used in various systems involved. This information may or may not be duplicated on the plans, but equipment shown on either plans or riser diagrams and schematics shall be provided as if shown on both.
 2. All grades, elevations, dimensions, and clearances of equipment shown on drawings are approximate and shall be verified at site.
 3. Where work or equipment is referred to in singular terms, such reference shall be deemed to apply to as many items of work or equipment as required to complete entire installation.
- 3.3 LINES AND GRADES:
 - A. Lay out work and establish heights and grades for work in strict accordance with the intent expressed by the drawings and all the physical conditions at the building and be responsible for the accuracy of same.
- 3.4 FIELD MEASUREMENTS:
 - A. Before ordering any material or doing any work, verify all measurements at the building and site and be responsible for the correctness of same. No extra compensation will be allowed on account of differences between actual dimensions and measurements and those indicated on the drawings. Any difference which may be found shall be submitted to the Design Professional for consideration before proceeding any further with the work.
- 3.5 DELIVERY OF EQUIPMENT:
 - A. Be responsible for delivery of equipment, unload and store in a manner not to interfere with the operation of other trades. Additional expense incurred because of equipment or material delivery delays shall be assumed by the responsible Contractor.
- 3.6 PROTECTION OF WORK:
 - A. All work, equipment and materials shall be protected at all times. All piping openings shall be closed with caps or plugs during installation. All equipment shall be tightly covered and protected against dirt, water, plaster, paint and other foreign material or mechanical injury during entire progress of installation. Make good all damage caused either directly or indirectly by workmen employed to fulfill requirements of the Plumbing Work.
- 3.7 REMOVAL OF RUBBISH:
 - A. During the course of construction, periodically remove from the premises all rubbish resulting from work of this trade so as to prevent its accumulation. At the completion of the work

contemplated under these Specifications remove from the building and site all rubbish and accumulated materials of whatever nature not caused by the other trades and leave work, and equipment free of all foreign matter including plaster, cement, and paint and leave in a clean, orderly, acceptable, and usable condition.

3.8 COORDINATION:

- A. Work in conjunction with each of the other trades to facilitate proper and intelligent execution of work with minimum interference.
- B. Carefully examine all architectural and structural drawings for the building and drawings for electrical trade and other mechanical trades and be responsible for the proper fitting of all material and equipment into the building as planned and without interference with other piping, ductwork, conduit, or equipment. Proper judgment shall be exercised to secure best possible headroom, door and window clearance, and space conditions throughout; to secure neat arrangement for piping, equipment, and conduit; and to overcome all local difficulties and interferences to best advantage. Approval for any and all changes to plans and specifications which may thus be incurred shall be obtained from the Design Professional before proceeding.
- C. Contractor shall prepare preliminary shop drawings suitable for use in coordinating their work with the work of other trades. The HVAC section will prepare and furnish CAD files of drawings prepared at $3/8" = 1'-0"$ scale with all trades indicating piping, ductwork and conduit in relation to all structural elements of the construction, including floor elevations; steel locations, size, and elevations; partitions locations; door locations and direction of swing; and all other information required to assure coordination of the electrical, sheet-metal and piping trades and fire protection in relation to the Architectural function of the project. Coordination meetings will be held under the supervision of the Owner's Construction Manager and General Contractor. Each trade shall have proper representation at all coordination meetings for the purpose of detailing, on a print of the CAD drawing mentioned above, the exact location and routing of their work. After the conclusion of the coordination at the working meetings, each trade shall sign the coordinated print, copies of which shall be distributed by the GC to all contractors and parties concerned including the Owner. The final shop drawings of all trades shall be revised to be in accordance with the coordinated drawing. A print of each final coordinated CAD shop drawings with the participating contractors "sign off" signatures appended shall be submitted to the Design Professional for final record.
- D. If contractor installs work so as to cause interference with work of other trades, they shall make necessary changes in work to correct the condition without extra charge.
- E. Dimensional layout plans of equipment rooms shall be made showing all bases, pads and inertia blocks required for mechanical equipment. Include dimensions of bases, bolt layouts, details, etc.
- F. Contractor shall furnish all necessary templates, patterns, etc. for installing work and for purpose of making adjoining work conform, furnish setting plans and shop details to other trades as required.

3.9 COORDINATION OF CONTROL EQUIPMENT:

- A. The Plumbing Contractor shall furnish all starters, push buttons for local or remote control, controllers, pressure switches, aquastats, thermostats, float switches or similar items together with all appurtenances and accessories required to operate the equipment furnished under these specifications and necessary to perform the operating functions as specified shown on the drawings, or otherwise required.

- B. Refer to equipment specification for type of controls required. The Electrical Contractor will mount and provide power-wiring for all starters and will furnish and install all other safety switches or other line-disconnecting or protective devices. Where the starter and/or safety switch is an integral part of the equipment assembly, the assembly shall be furnished with the wiring complete between starter, controller and motor and the Electrical Contractor will make power connections only.
- C. All control wiring to automatic-operated switches, pressure switches, aquastats or other devices which actuate the starter or other items associated with the systems shall be furnished, installed, and wired by the Plumbing Contractor. The Electrical Contractor will supply 120V electric power to the control panels for these special systems to the extent shown on Electrical Drawings. All other wiring (including additional power circuit if required) shall be the responsibility of the Plumbing Contractor.
- D. The Plumbing Contractor shall carefully check the current characteristics available to each location before ordering motors.
- E. If procurement requirements necessitate a change in voltage, phase, size or other characteristics of any motor, the Plumbing Contractor shall obtain approval of such change from the Design Professional and shall be responsible for necessary arrangements for notifying the Electrical Contractor, and shall pay the costs, if any, required by the change, including Engineering costs.
- F. All electrical equipment furnished and installed under this contract shall be furnished with full complement of control equipment, control wiring, conduit, and all other items necessary for satisfactory operation.
- G. The Electrical Contractor will complete all electrical power connections, through the disconnect and/or thermal cutouts, starter, and motor terminals. They will be responsible for final power connections.
- H. The Electrical Contractor will be responsible for proper rotation of three phase equipment.
- I. All electrical work, equipment and material furnished under this Section shall be furnished and installed in accordance with Sections 16000 and 16100 of the Electrical Specifications.
- J. All panels, relays, terminal boxes, contactors, circuit breakers, safety switches, motor starters and similar items shall be identified by Name, Function and/or Control. Nameplates shall be at least 1" x 3" with characters not less than 1/4". They shall be made of two laminated black plastic sheets bonded with a middle sheet of white plastic and characters engraved in one black sheet to the depth of the white plastic. A typewritten list of Nameplates shall be submitted to the Design Professional for approval before ordering same.

3.10 EXPANSION OF PIPING:

- A. All piping connections shall be made so as to allow for perfect freedom of movement of piping during expansion and contraction, without springing or creating air pockets which will impair the flow of the water through the system. Install expansion loops as shown on the drawings as required. Expansion loops shall be made with swing joints, bends or long offsets, as necessary. Provide expansion guides.

3.11 ANCHORS AND GUIDES:

- A. Anchors shall be provided where shown and/or required for the proper control of stress in piping due to expansion. Anchors shall be made of heavy cross section and securely fastened to concrete construction by anchor bolts set in concrete before pouring or bolted or

welded to building structural steel. Submit shop drawings of anchor details for approval. Provide guides, Metraflex Style I, II, and III, Adasco or approved equal; wrap duct tape between copper tubing and guide clamp.

3.12 LOCATIONS:

- A. All plumbing fixtures and other equipment shall be in the exact locations directed by the Architect and Design Professional. It shall be the duty of the Contractor to request such exact locations sufficiently in advance of the time when such information will be required at the building so as to not interfere with the progress of this work and that of the contractors under other specifications. Elevation of plumbing fixtures shall be as shown on the Architectural Drawings.

3.13 FIRE STOPPING:

- A. All penetrations through fire-resistance-rated floor, fire resistance rated, floor/ceiling assemblies and roof construction and through fire-resistance-rated walls and partitions shall be fire stopped.
- B. Penetrations to be fire stopped include both empty openings and those containing cables, pipes, ducts, conduits, and any other items.
- C. Fire rating of sealed penetrations shall meet or exceed the rating of the assembly being penetrated.
- D. Materials shall be installed in accordance with manufacturer's recommendations and their UL listing.

3.14 SEISMIC RESTRAINTS:

- A. All plumbing equipment and material required by applicable Codes to be installed or supported in accordance with seismic restraint criteria shall be installed in accordance with this Article. This applies to equipment or materials specified in other Division 15 Specification sections as well as to materials specified in this section.
- B. Seismic restraint calculations must be performed and certified by a registered professional engineer whose practice comprises the design of seismic restraints. Calculations must identify equipment or materials requiring such restraints, and shall include calculated dead loads, derived loads, and materials used for connection to equipment and structures. Analysis shall include anchoring methods, sizes of fasteners and connections, embedments, weld details, etc.
 - 1. The building location is in an area with Effective Peak Velocity Related Acceleration Coefficient (A_v) of _____. The building is in Seismic Hazard Exposure Group _____ and must meet Seismic Performance Category _____.
 - 2. All supports, restraints, fasteners, and attachments shall meet the criteria in subparagraph 1, above, as well as complying with the component Seismic coefficient (C_c) and Performance Criteria Factor (P) for the specific equipment, devices, or system involved.
 - 3. Seismic Engineer shall provide a seismic design Errors and Omissions insurance certificate.
- C. Contractor shall provide hangers, isolators, supports, restraints, etc., from a single manufacturer of such products. Such manufacturer shall certify in writing that the products provided by them meet the requirements specified or calculated by the Seismic Engineer for the specific application. Manufacturer shall be responsible for:

1. Determining restraint sizes and locations.
2. Providing restrain products to meet the requirements of the specific application.
3. Guaranteeing performance of the products supplied.
4. Providing installation instructions, drawings, and field supervision to the contractor to ensure proper installation of the products; and
5. Certifying correctness of installation of the products upon completion and identifying for correction any items or areas not properly applied.

3.15 COMMISSIONING

- A. The installing contractor shall provide a field technician and specialized tools to facilitate a successful site system commissioning and testing for all equipment and systems. This contractor and technician shall be part of the overall commissioning team. Where applicable and required, the contractor shall secure and pay for a factory technician to be part of the startup, testing and commissioning team and efforts.
1. All equipment shall be commissioned, and the operation of that equipment shall be checked by the installing contractor. Specific systems shall be commissioned when more than one contractor is involved in the installation or there is multiple system interface and control involved with that piece of equipment.
 2. The contractors shall check and verify all equipment nameplate data against the design parameters, prior to installation.
 3. The contractors shall submit a Spare Parts List for all equipment in the Maintenance and Operations Manuals to include, but not limited to the following:
 - a. Part Numbers
 - b. Part and Equipment Description
 - c. Quantity of Parts Required
 - d. Lubrication Requirements
 - e. Full Warranty Information
 - f. Complete Operation and Maintenance Manuals

END OF SECTION

SECTION 220005

COORDINATION DRAWING REQUIREMENTS FOR PLUMBING

PART 1 - GENERAL

1.1 COORDINATION DRAWINGS

- A. All mechanical, electrical, plumbing, fire protection, telecommunications, and ATC subcontractors will be required to use AutoCAD (CAD) format. Coordination drawings will be distributed via email and/or disk.

1.2 ABOVE CEILING AND NO CEILING OVERHEAD INSTALLATION

- A. The Mechanical Contractor shall furnish minimum 1/4 inch scale CAD electronic background drawings of the sheet-metal shop drawings, for incorporation of plumbing and mechanical piping services. All ductwork and piping systems shall be thoroughly dimensioned as to location and height above finished floor. Each different system will be drawn in a different color. Upon conclusion of the various systems coordination with the Sheet-Metal Contractor, the composite drawing shall be distributed by the Construction Manager for contractor coordination. All lighting fixture locations will be "ghosted in" by the Sheet-Metal Contractor for coordination of the same. The Sheet-Metal Contractor shall prepare a title box on each drawing which allows space for the signature of the authorized individual from the Sheet-Metal, HVAC Piping, Plumbing, Fire Protection, Electrical, Telecommunications and ATC firms, with the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

NOTE: The composite drawing is in addition to separate shop drawings to be submitted at the conclusion of the coordination process.

- B. At the conclusion of each composite drawing coordination process, the Construction Manager shall be notified by the Mechanical Contractor Project Manager. The Mechanical Contractor Project Manager shall then schedule an on-site coordination meeting for the purpose of signing off on the respective drawing. The Mechanical Contractor shall not be authorized to release any material for fabrication or installation until the composite drawing signature process is executed or until Construction Manager authorizes, in writing, a portion of the work to proceed.
- C. The Mechanical Contractor shall print a weekly status log and maintain a file for the project on this process. Each subcontractor is responsible to submit and coordinate their work with the Construction Manager and Mechanical Contractor.
- D. The Fire Protection Contractor shall overlay their complete piping system on a composite background drawing furnished by the Mechanical Contractor. The Fire Protection Contractor shall utilize a different color from that previously used by the HVAC and Plumbing draftsmen. The Fire Protection Contractor shall cooperate in the coordination process by the relocation of their piping as required to facilitate coordination. When completed, Sprinkler Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the

entire coordination process, the Fire Protection Contractor shall be responsible for attending a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signatures to the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

NOTE: The composite drawing is in addition to a separate sprinkler piping shop drawing to be submitted at the conclusion of the coordination process.

- E. The Electrical Contractor shall be responsible to overlay their major conduit racks and equipment, as well as verifying all lighting fixture locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. All conduits larger than 2 inch shall be documented. When completed, Electrical Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Electrical Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signature to the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

- F. The Plumbing Contractor will be responsible to overlay their major piping racks and equipment, as well as verifying all plumbing fixture locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. When completed, Plumbing Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Plumbing Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signature to the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

- G. The Telecommunication Contractor will be responsible to overlay their major communication racks and cable tray, as well as verifying locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. When completed, Telecommunication Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Telecommunication Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of their authorized personnel affixing their signature to the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

- H. Provide survey and coordination of underground plumbing for verification of location.

- I. Drawings, if available, may be obtained electronically from the Architect through the Construction Manager.
- J. The Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC Contractors shall receive hard copies of all drawings.
- K. The Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC Contractors shall review all drawings and advise if any additional drawings are needed.
- L. The Mechanical Trade Contractor shall take the lead and develop a drawing list for submissions and a submission schedule coordinated with the construction activities. The drawings shall be developed in a sequential fashion so as to no delay installation of the work or the overall project schedule. The lead Mechanical trade contractor shall include a master key plan so that the area of each drawing can be readily identified as to the location within each building. The Plumbing trade contractor shall lead the underground coordination and the HVAC trade contractor shall lead the balance of the coordination work. The drawing list and schedule shall be forwarded to the Construction Manager for review.
- M. Pursuant to Construction Manager approval of the list and schedule, the Mechanical trade contractor shall provide to all participants the latest plans in a timely fashion in accordance with their schedule.
- N. Prior to the start of the work, each subcontractor shall forward an insulation schedule to the Construction Manager M.E.P. Coordinator. The schedule shall show the size and thickness of each type of insulation and its intended use.

1.3 ACCESS FLOOR INSTALLATION

- A. Coordination drawings for systems to be installed in the access floor shall be prepared in the same manner as described for the overhead installation.

1.4 SHEET-METAL / PIPING / ATC / ELECTRICAL ACCESS / MAINTENANCE CLEARANCES

- A. As soon as practical, the Mechanical trade contractor shall prepare layout drawings (not less than 3/8 inch scale) of all ductwork and piping. These drawings shall show all WALL FIRE RATINGS, registers, grilles, diffusers, and similar features, as well as locations of all valves, dampers, damper operators and other items requiring access for maintenance. It shall also be the responsibility of the Mechanical trade contractor to show on these drawings; beams with bottom elevations, ceiling heights, wall-to-wall dimensions, partitions, columns, windows, doors, electric lighting layouts as shown on the reflected ceiling plans, acoustical ceiling grid, and other major architectural and structural features as shown on the General Construction Drawings. All dimensions should be from centerlines of columns. All required access to equipment for service and/or required for NEC code required clearances shall be shown in a dotted zone.
- B. The Mechanical trade contractor, upon completion of their work, shall email their data back to the Plumbing trade contractor and copy all participants. The Plumbing trade contractor shall download the mechanical data and incorporate, by separate layer, their own routing, as well as other areas requiring access for service and maintenance to determine their relationship and possible interferences with the mechanical, architectural, or structural features to be performed as part of the work.

- C. The Plumbing trade contractor shall then email their data to the Electrical trade contractor and copy all participants. The Electrical trade contractor shall download the drawing and incorporate, by separate layer, their own routings, as well as the depth of all light fixtures, access panels, etc., as required to determine the relationship and possible interferences with plumbing, mechanical, architectural, or structural items to be installed as part of the overall work. The Electrical trade contractor shall be responsible to verify that the electrical lighting layout shown on these drawings is correct and to make corrections and additions of all other light fixtures as required. In areas where no mechanical work occurs, but where other crowded electrical installations are evident, the Electrical trade contractor shall prepare similar drawings.
- D. The Electrical trade contractor shall then email the Fire Protection trade contractor and copy all participants. The Fire Protection trade contractor shall download the drawing and incorporate, by separate layer, their own routings, as well as other areas requiring access for service and maintenance, to determine their relationship and possible interferences with the mechanical, electrical, plumbing, and architectural or structural items to be installed as part of the overall work.
- E. The Mechanical trade contractor shall provide one composite set of reproducible drawings and forward them to the Construction Manager. This composite shall then be reviewed during meetings determined by the Construction Manager, at which all subcontractors including their subcontractors, as required by the Construction Manager, shall be represented to review, and resolve any real or apparent interference or conflicts.
- F. In the preparation of all the final composite drawings, large scale details, as well as cross and longitudinal sections shall be made as required to fully delineate all conditions. Particular attention shall be given to the locations, size and clearance dimensions of equipment items, shafts, and similar features. The final composite drawings shall include the locations of all controls, tie-ins, connections for other subcontractor's work, and pipe and duct insulation as required.
- G. Final composite drawings shall then be signed off by each trade subcontractor indicating their acceptance and approval of the indicated routings and layouts and their relationship with the adjoining or contiguous work of all subcontracts. Thereafter, no unauthorized deviations shall be permitted. If deviations are made without the knowledge and agreement of Construction Manager and other affected trade contractors, the work in question shall be subject to removal and correction at no additional cost.
- H. In preparing the composite drawings, minor changes in duct, pipe or conduit routings that do not affect the intended function may be made as required to avoid space conflicts, when mutually agreed. Items may not be resized, exposed items relocated, or items run exposed when not intended, without approval. No changes shall be made in any structural members or architectural features which affect the function or aesthetics of the buildings. If conflicts or interferences cannot be satisfactorily resolved, the Engineer shall be notified, and their decision obtained.
- I. After final composite drawings have been accepted and approved, and signed by ALL subcontractors, the Mechanical trade contractor shall provide and distribute one sepia and two prints to each of the subcontractors, and one sepia and four prints each to Construction Manager. Subcontractors requiring further prints for their own distribution will possess sepias to accomplish same. The original signed-off mylars shall be sent to Construction Manager for permanent possession.

- J. The record copies of final composite drawings shall be retained by each subcontractor as a working reference. All shop drawings, prior to their submittal to Construction Manager, shall be compared with the composite drawings and developed accordingly by the subcontractor responsible. Any revisions to the composite drawings, which may become necessary during the process of the work, shall be noted by all subcontractors, and shall be neatly and accurately recorded on the record copies. Each trade contractor shall be responsible for the up-to-date maintenance of their own record copies of the composite drawings and to keep one copy available at the site. The composite drawings and any subsequent changes thereto, shall be utilized by each subcontractor in the development of their as-built drawings. NOTE: The coordination drawings may be used with appropriate changes as as-builts and changes to title block.
 - K. Preparation of coordination drawings shall commence as soon as possible after award of the subcontract. The coordination drawings may lack complete data in certain instances pending receipt of equipment drawings, but sufficient space shall be allotted for the items affected. When final information is received, such data shall be promptly inserted on the composite by that trade contractor.
 - L. Coordination is the responsibility of all trade contractors. Construction Manager will call meetings, weekly, or as required, which subcontractors must attend to avoid delay. Failure to attend shall require the trade contractor to field run the work not coordinated. No extra compensation will be paid to any trade contractor for relocating any duct, pipe, conduit, or other material that has been installed without proper coordination. If the installation of any uncoordinated work or improper installation or coordinated work necessitates additional work by other subcontractors, at the cost of such additional work shall be assigned to the trade contractor responsible as determined by Construction Manager.
 - M. All changes in the work of any subcontract shall be shown on the composite drawings.
 - N. All work on the coordination composite drawings shall be performed by competent CAD operators, in a clear legible manner. Each trade contractor shall execute a typical drawing activity in no more than three working days. It shall be the responsibility of each subcontractor to supply a sufficient number of CAD operators so as not to delay the coordination process. Construction Manager and Engineer shall be the judge of the acceptability of the drawings.
 - O. The composite drawings shall not be used for as-built drawings. (See Paragraph above)
 - P. It shall be further understood that each trade contractor's specified submittals shall be transmitted for approval during the coordination period in order that the project encounter no delays.
 - Q. The Mechanical trade subcontractor shall pre-coordinate all control equipment locations with the designated ATC trade subcontractor and indicate it on the composite document.
- 1.5 REQUIREMENTS
- A. All Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC trade contractors shall be required to use AutoCAD (CAD) format. Coordination drawings shall be distributed via email or diskettes. ALL EMAILS SHALL BE COPIED TO CONSTRUCTION MANAGER, ENGINEER, AND PROJECT MANAGER.
 - B. The Sheet-Metal trade contractor shall prepare a title box on each drawing which allows space for the signature of the authorized individual from the sheet-metal, HVAC, piping, plumbing, sprinkler, electrical and ATC firms with the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

- C. The Mechanical trade contractor shall not be authorized to release any material for fabrication or installation until the composite drawing signature process is executed or until Construction Manager authorizes, in writing, a portion of the work to proceed.
- D. The Mechanical Contractor shall print a weekly status of all emails sent and received and maintain a hard copy file for use at the coordination "sign-off" meetings. Each subcontractor is required to check emails daily.
- E. Submittals: Once the coordination process has been completed, the coordination drawings shall be submitted to the Engineer for review. A single-color plot, as well as three blueprint copies of the drawings shall be submitted for review. The color plot shall delineate between the various disciplines by utilizing different color pens for each system.

PART 2 – PRODUCTS (NOT USED)

PART 3 – EXECUTION (NOT USED)

END OF SECTION

SECTION 220513

COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.2 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Premium efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.

- D. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Match insulation rating.
- I. Insulation: Class F.
- J. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.
- K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.3 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
 - 2. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 3. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.4 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
 - 2. Split phase.
 - 3. Capacitor start, inductor run.
 - 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (NOT USED)

END OF SECTION

SECTION 220517

SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Sleeves.
 - 2. Stack-sleeve fittings.
 - 3. Sleeve-seal systems.
 - 4. Sleeve-seal fittings.
 - 5. Grout.
 - 6. Silicone sealants.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.
- C. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, galvanized, with plain ends and integral welded waterstop collar.
- D. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.2 SLEEVE-SEAL FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Advance Products & Systems, Inc.
 - 2. CALPICO, Inc.

3. GPT; an EnPro Industries company.
4. Metraflex Company (The).
5. Proco Products, Inc.

- B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall.

2.3 GROUT

- A. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 2. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
 3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
1. Cut sleeves to length for mounting flush with both surfaces.
 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.

3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.
- E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
 1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 5. Use silicone sealant to seal the space around outside of stack-sleeve fittings.
- B. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Use silicon seal to seal the space around outside of sleeve-seal fittings.

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:

1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
 - B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.
 - C. Prepare test and inspection reports.
- 3.6 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 1. Concrete Slabs-on-Grade:
 - a. Piping Smaller Than NPS 6.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 2. Concrete Slabs above Grade:
 - a. Piping Smaller Than 4 inch: Steel pipe sleeves.
 - b. Piping 4 inch and Larger: Steel pipe sleeves.
 3. Interior Partitions:
 - a. Piping Smaller Than 4 inch: Steel pipe sleeves PVC pipe sleeves.
 - b. Piping 4 inch and Larger: Galvanized-steel sheet sleeves.

END OF SECTION

SECTION 220518

ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Escutcheons.
 - 2. Floor plates.

1.3 DEFINITIONS

- A. Existing Piping to Remain: Existing piping that is not to be removed and that is not otherwise indicated to be removed and salvaged or removed and reinstalled.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. BrassCraft Manufacturing Co.; a Masco company.

2.2 ESCUTCHEONS

- A. One-Piece, Cast-Brass Type: With chrome-plated finish and setscrew fastener.

2.3 FLOOR PLATES

- A. Split Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.
 - 1. Escutcheons for New Piping and Relocated Existing Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
 - b. Chrome-Plated Piping: One-piece cast brass with polished, chrome-plated finish.
 - c. Insulated Piping: One-piece cast brass with chrome-plated finish.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece cast brass with chrome-plated finish.
 - e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece cast brass with chrome-plated finish.
 - f. Bare Piping in Unfinished Service Spaces: One-piece cast brass with rough-brass finish.
 - g. Bare Piping in Equipment Rooms: One-piece cast brass with rough-brass finish.
 - 2. Escutcheons for Existing Piping to Remain:
 - a. Insulated Piping: Split-plate, stamped steel with concealed hinge with chrome-plated finish.
 - b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped steel with concealed hinge with chrome-plated finish.
 - c. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped steel with concealed hinge with chrome-plated finish.
 - d. Bare Piping in Unfinished Service Spaces: Split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.
- C. Install floor plates for piping penetrations of equipment-room floors.
- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. New Piping: One-piece, floor plate.
 - 2. Existing Piping: Split floor plate.

3.2 FIELD QUALITY CONTROL

- A. Using new materials, replace broken and damaged escutcheons and floor plates.

END OF SECTION

SECTION 220519

METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Bimetallic-actuated thermometers.
2. Filled-system thermometers.
3. Liquid-in-glass thermometers.
4. Light-activated thermometers.
5. Thermowells.
6. Dial-type pressure gages.
7. Gage attachments.
8. Test plugs.
9. Test-plug kits.
10. Sight flow indicators.

- B. Related Requirements:

1. Section 221119 "Domestic Water Piping Specialties" for water meters.
2. Section 221513 "General-Service Compressed-Air Piping" for compressed air gages.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of meter and gage.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ashcroft Inc.
 - 2. Terice, H. O. Co.
- B. Standard: ASME B40.200.
- C. Case: Liquid-filled and sealed type(s); stainless steel with 5-inch nominal diameter.
- D. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F.
- E. Connector Type(s): Union joint, adjustable angle, with unified-inch screw threads.
- F. Connector Size: 1/2 inch, with ASME B1.1 screw threads.
- G. Stem: 0.25 or 0.375 inch in diameter; stainless steel.
- H. Window: Plain glass.
- I. Ring: Stainless steel.
- J. Element: Bimetal coil.
- K. Pointer: Dark-colored metal.
- L. Accuracy: Plus or minus 1 1 percent of scale range.

2.2 FILLED-SYSTEM THERMOMETERS

- A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ashcroft Inc.
 - b. Terice, H. O. Co.
 - 2. Standard: ASME B40.200.
 - 3. Case: Sealed type, cast aluminum, 4-1/2-inch nominal diameter.
 - 4. Element: Bourdon tube or other type of pressure element.
 - 5. Movement: Mechanical, dampening type, with link to pressure element and connection to pointer.
 - 6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
 - 7. Pointer: Dark-colored metal.
 - 8. Window: Glass.

9. Ring: Stainless steel.
10. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device; with ASME B1.1 screw threads.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - a. Design for Thermowell Installation: Bare stem.
12. Accuracy: Plus or minus 1 percent of scale range.

2.3 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ashcroft Inc.
 - b. Terice, H. O. Co.
 - c. Weiss Instruments, Inc.
 - d. Weksler Glass Thermometer Corp.
2. Standard: ASME B40.100.
3. Case: Liquid-filled relief type(s); cast aluminum; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Stainless steel.
11. Accuracy: plus or minus 1 percent of middle half of scale range.

2.4 GAGE ATTACHMENTS

- A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and **[porous-metal]**-type surge-dampening device. Include extension for use on insulated piping.
- B. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.5 TEST PLUGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Terice, H. O. Co.
 2. Weiss Instruments, Inc.
 3. Weksler Glass Thermometer Corp.

- B. Description: Test-station fitting made for insertion into piping tee fitting.
- C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
- D. Thread Size: NPS 1/2, ASME B1.20.1 pipe thread.
- E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.
- F. Core Inserts: EPDM self-sealing rubber.

2.6 TEST-PLUG KITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Terice, H. O. Co.
 - 2. Weiss Instruments, Inc.
- B. Furnish one test-plug kit(s) containing one thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.
- C. High-Range Thermometer: Small, bimetallic insertion type with 4 1/2 inch diameter dial and tapered-end sensing element. Dial range shall be at least 50 to 150 deg F.
- D. Pressure Gage: Small, Bourdon-tube insertion type with 2 inch diameter dial and probe. Dial range shall be at least 0 to 200 psig.
- E. Carrying Case: Metal or plastic, with formed instrument padding.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install thermometers in the following locations:
 - 1. Inlet and outlet of each water heater.
 - 2. Inlet and outlet of each domestic hot-water storage tank.
 - 3. Inlet and outlet of each mixing valve and circulator.
- B. Install pressure gages in the following locations:
 - 1. Inlet and outlet of each pressure-reducing valve and pressure regulating valve
 - 2. At inlet of each gas fired equipment.

3.2 CONNECTIONS

- A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

3.3 ADJUSTING

- A. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCALE-RANGE SCHEDULE

- A. Scale Range for Domestic Cold-Water Piping: 0 to 100 deg F.
- B. Scale Range for Domestic Hot-Water Piping: 40 to 200 deg F.
- C. Scale Range for Domestic Hot-Water Piping: 30 to 240 deg F.

3.5 PRESSURE-GAGE SCHEDULE

- A. Pressure gages at discharge of each water service into building shall be one of the following:
 - 1. Liquid-filled direct-mounted, metal case.
- B. Pressure gages at inlet and outlet of each water pressure-reducing valve shall be the following:
 - 1. Liquid-filled, direct-mounted, metal case.

3.6 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range for Water Service Piping: 0 to 160 psi.
- B. Scale Range for Domestic Water Piping: 0 to 160 psi.

END OF SECTION

SECTION 22 05 23

VALVES AND SPECIALTIES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Brass ball valves.
2. Iron gate valves.
3. Bronze swing check valves.
4. Iron swing check valves.
5. Iron, center-guided check valves.
6. Balancing valves.
7. Strainers.
8. Drain valves.
9. Water-hammer arresters.
10. Air vents.
11. Flexible connectors.

1.3 DEFINITIONS

- A. CWP: Cold working pressure.
- B. NRS: Non-rising stem.
- C. OS & Y: Outside screw and yoke.
- D. RS: Rising stem

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of valve.
 1. Certification that products comply with NSF 61 Annex G and NSF 372.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 1. Protect internal parts against rust and corrosion.
 2. Protect threads, flange faces, and soldered ends.
 3. Set ball valves open to minimize exposure of functional surfaces.
 4. Set gate valves closed to prevent rattling.
 5. Set check valves in either closed or open position.

- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 - 1. ASME B1.20.1 for threads for threaded end valves.
 - 2. ASME B16.1 for flanges on iron valves.
 - 3. ASME B16.5 for flanges on steel valves.
 - 4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 5. ASME B16.18 for solder-joint connections.
 - 6. ASME B31.9 for building services piping valves.
- C. NSF Compliance: NSF 61 Annex G and NSF 372 for valve materials for potable-water service.
- D. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- F. Valve Sizes: Same as upstream piping unless otherwise indicated.
- G. Valve Actuator Types:
 - 1. Handlever: For quarter-turn valves smaller than NPS 4.
- H. Valves in Insulated Piping:
 - 1. Include 2-inch stem extensions.
 - 2. Extended operating handles of nonthermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
 - 3. Memory stops that are fully adjustable after insulation is applied.
- I. RS Valves in Insulated Piping: With 2-inch stem extensions.
- J. Valve Bypass and Drain Connections: MSS SP-45

2.2 BRASS BALL VALVES

- A. Two-Piece, Brass Ball Valves with Full Port and Brass Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Milwaukee Valve Company.
 - c. NIBCO INC.
 - d. Watts; a Watts Water Technologies company.
 2. Description:
 - a. Standard: MSS SP-110.
 - b. CWP Rating: 600 psig.
 - c. Body Design: Two piece.
 - d. Body Material: Forged brass.
 - e. Ends: Threaded and soldered.
 - f. Seats: PTFE.
 - g. Stem: Brass.
 - h. Ball: Chrome-plated brass.
 - i. Port: Full.
- B. Three-Piece, Brass Ball Valves with Full Port and Brass Trim:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Milwaukee Valve Company.
 - c. Watts; a Watts Water Technologies company.
 2. Description:
 - a. Standard: MSS SP-110.
 - b. CWP Rating: 600 psig.
 - c. Body Design: Three piece.
 - d. Body Material: Forged brass.
 - e. Ends: Threaded and soldered.
 - f. Seats: PTFE.
 - g. Stem: Brass.
 - h. Ball: Chrome-plated brass.
 - i. Port: Full.
- C. Three-Piece, Brass Ball Valves with Full Port and Stainless-Steel Trim:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Marwin Valve; Richards Industries.
 - b. Jomar Valve.
 2. Description:
 - a. Standard: MSS SP-110.
 - b. CWP Rating: 600 psig.
 - c. Body Design: Three piece.

- d. Body Material: Forged brass.
- e. Ends: Threaded and soldered.
- f. Seats: PTFE.
- g. Stem: Stainless steel.
- h. Ball: Stainless steel, vented.
- i. Port: Full.

2.3 BRONZE SWING CHECK VALVES

A. Class 125, Bronze, Swing Check Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jomar Valve.
 - b. Conbraco Industries, Inc.
 - c. Jenkins Valves; Crane Energy Flow Solutions.
 - d. Macomb Groups (The).
 - e. Milwaukee Valve Company.
 - f. NIBCO INC.
 - g. Powell Valves.
 - h. Red-White Valve Corporation.
 - i. Watts; a Watts Water Technologies company.
2. Description:
 - a. Standard: MSS SP-80, Type 3.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Horizontal flow.
 - d. Body Material: ASTM B 62, bronze.
 - e. Ends: Threaded or soldered. See valve schedule articles.
 - f. Disc: Bronze.

B. Class 150, Bronze Swing Check Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jomar Valve.
 - b. Jenkins Valves; Crane Energy Flow Solutions.
 - c. Macomb Groups (The).
 - d. Milwaukee Valve Company.
 - e. NIBCO INC.
 - f. Red-White Valve Corporation.
 - g. Stockham; Crane Energy Flow Solutions.
2. Description:
 - a. Standard: MSS SP-80, Type 3.
 - b. CWP Rating: 300 psig.
 - c. Body Design: Horizontal flow.
 - d. Body Material: ASTM B 62, bronze.
 - e. Ends: Threaded or soldered. See valve schedule articles.
 - f. Disc: Bronze.

2.4 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jenkins Valves; Crane Energy Flow Solutions.
 - b. Milwaukee Valve Company.
 - c. NIBCO INC.
 - d. Powell Valves.
 - e. Stockham; Crane Energy Flow Solutions.
2. Description:
 - a. Standard: MSS SP-71, Type I.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Clear or full waterway.
 - d. Body Material: ASTM A 126, gray iron with bolted bonnet.
 - e. Ends: Flanged or threaded. See valve schedule articles.
 - f. Trim: Bronze.
 - g. Gasket: Asbestos free.

2.5 IRON, CENTER-GUIDED, SPRING-LOADED CHECK VALVES

A. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International.
 - b. Jomar Valve.
 - c. Crispin Valve.
 - d. DFT Inc.
 - e. Flo Fab inc.
 - f. GA Industries, Inc.
 - g. Hammond Valve.
 - h. Metraflex Company (The).
 - i. Milwaukee Valve Company.
 - j. Mueller Steam Specialty.
 - k. NIBCO INC.
 - l. Spence Strainers International.
 - m. Sure Flow Equipment Inc.
 - n. Val-Matic Valve & Manufacturing Corp.
 - o. Watts; a Watts Water Technologies company.
2. Description:
 - a. Standard: MSS SP-125.
 - b. CWP Rating: 200 psig.
 - c. Body Material: ASTM A 126, gray iron.
 - d. Style: Compact wafer, spring loaded.
 - e. Seat: Bronze.

B. Adjustable with Memory-Stop Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Hammond Valve.
 - c. Jenkins Valves; Crane Energy Flow Solutions.
 - d. Milwaukee Valve Company.
 - e. NIBCO INC.
 - f. Red-White Valve Corporation.
 - g. Stockham; Crane Energy Flow Solutions.
2. Circuit setter type with memory stop.
3. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
4. Pressure Rating: 400-psig minimum CWP.
5. Size: NPS 2 or smaller.
6. Body: Copper alloy.
7. Port: Standard or full port.
8. Ball: Chrome-plated brass.
9. Seats and Seals: Replaceable.
10. End Connections: Solder joint or threaded.
11. Handle: Vinyl-covered steel with memory-setting device.

2.6 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations unless otherwise indicated.
5. Perforation Size:
 - a. Strainers NPS 2 and Smaller: 0.020 inch.
 - b. Strainers NPS 2-1/2 to NPS 4: 0.045 inch.
 - c. Strainers NPS 6 and Larger: 0.10 inch.
6. Drain: Factory-installed, hose-end drain valve.

2.7 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

B. Gate-Valve-Type, Hose-End Drain Valves:

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1. Standard: MSS SP-80 for gate valves.
2. Pressure Rating: Class 125.
3. Size: NPS 3/4.
4. Body: ASTM B 62 bronze.
5. Inlet: NPS 3/4 threaded or solder joint.
6. Outlet: Garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

C. Stop-and-Waste Drain Valves:

1. Standard: MSS SP-110 for ball valves or MSS SP-80 for gate valves.
2. Pressure Rating: 200-psig minimum CWP or Class 125.
3. Size: NPS 3/4.
4. Body: Copper alloy or ASTM B 62 bronze.
5. Drain: NPS 1/8 side outlet with cap.

2.8 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Zurn Industries, LLC.
2. Standard: PDI-WH 201.
3. Size: PDI-WH 201, Sizes A through F.

2.9 AIR VENTS

A. Bolted-Construction Automatic Air Vents:

1. Body: Bronze.
2. Pressure Rating and Temperature: 125-psig minimum pressure rating at 140 deg F.
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Size: NPS 1/2 minimum inlet.
6. Inlet and Vent Outlet End Connections: Threaded.

B. Welded-Construction Automatic Air Vents:

1. Body: Stainless steel.
2. Pressure Rating: 150-psig minimum pressure rating.
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Size: NPS 3/8 minimum inlet.
6. Inlet and Vent Outlet End Connections: Threaded.

2.10 FLEXIBLE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Flex Pression Ltd.

2. Flex-Hose Co., Inc.
 3. Flexicraft Industries.
 4. Flex-Weld, Inc.
 5. Hyspan Precision Products, Inc.
 6. Mercer Gasket & Shim, Inc.
 7. Metraflex Company (The).
 8. Proco Products, Inc.
 9. Tozen Corporation.
 10. Unaflex.
 11. Universal Metal Hose.
- B. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
1. Working-Pressure Rating: Minimum 200 psig.
 2. End Connections NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
 3. End Connections NPS 2-1/2 and Larger: Flanged copper alloy.
- C. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.
1. Working-Pressure Rating: Minimum 200 psig.
 2. End Connections NPS 2 and Smaller: Threaded steel-pipe nipple.
 3. End Connections NPS 2-1/2 and Larger: Flanged steel nipple.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- A. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- B. Examine threads on valve and mating pipe for form and cleanliness.
- C. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- D. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.

- D. Install valves in position to allow full stem movement.
- E. Install valve tags. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.
- F. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
 - 1. Locate backflow preventers in same room as connected equipment or system.
 - 2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
 - 3. Do not install bypass piping around backflow preventers.
- G. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.
- H. Install balancing valves in locations where they can easily be adjusted.
- I. Where installing non-adjustable or adjustable balancing valves, install a combination of non-adjustable or adjustable balancing valves in conjunction with memory stop type balancing valves as recommended by the manufacturer.
- J. Install temperature-actuated, water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
- K. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve, and pump.
- L. Install outlet boxes recessed in wall or surface mounted on wall. Install 2-by-4-inch fire-retardant-treated-wood blocking, wall reinforcement between studs.
- M. Install water-hammer arresters in water piping according to PDI-WH 201.
- N. Install air vents at high points of water piping. Install drain piping and extend to appropriate location.
- O. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

3.3 CONNECTIONS

- A. Comply with requirements for ground equipment in Section 260526 "Grounding and Bonding for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:

1. Test each reduced-pressure-principle backflow preventer, double-check, backflow-prevention assembly according to authorities having jurisdiction and the device's reference standard.
 - B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.
 - C. Prepare test and inspection reports.
- 3.5 ADJUSTING
- A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and performing balancing. Replace valves if persistent leaking occurs.
 - B. Set field-adjustable pressure set points of water pressure-reducing valves.
 - C. Set field-adjustable flow set points of balancing valves and provide balancing report.
 - D. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.
- 3.6 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS
- A. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.
 - B. Use gate valves for shutoff service only.
 - C. Select valves with the following end connections:
 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
- 3.7 PUMP-DISCHARGE CHECK VALVE SCHEDULE:
- A. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
 - B. NPS 2-1/2 and Larger for Domestic Water: Iron swing check valves with lever and weight or spring; or iron, center-guided, metal-seat check valves.
 - C. NPS 2-1/2 and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.
- 3.8 DOMESTIC HOT- AND COLD-WATER BALL VALVE SCHEDULE
- A. Pipe NPS 2 and Smaller:
 1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
 2. Two-piece, brass ball valves with full port and brass trim.
 - B. Pipe NPS 2-1/2 and Larger:
 1. Three-piece, brass ball valves with full port and brass trim.

3.9 DOMESTIC HOT- AND COLD-WATER GATE VALVE SCHEDULE

- A. Pipe NPS 2-1/2 and Larger: Iron gate valves, OS&Y with flanged ends.

3.10 3.10 DOMESTIC HOT- AND COLD-WATER CHECK VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller: Bronze swing check valves, bronze disc with soldered or threaded end connections.
- B. Pipe NPS 2-1/2 and Larger:
 - 1. Iron, center-guided check valves, globe, metal seat with threaded or flanged end connections.

END OF SECTION

SECTION 220529

HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Fiberglass pipe hangers.
4. Metal framing systems.
5. Fiberglass strut systems.
6. Thermal hanger-shield inserts.
7. Fastener systems.
8. Pipe stands.
9. Pipe-positioning systems.
10. Equipment supports.

B. Related Requirements:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 220516 "Expansion Fittings and Loops for Plumbing Piping" for pipe guides and anchors.
3. Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.3 ACTION SUBMITTALS

- A. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Fiberglass strut systems.
4. Pipe stands.
5. Equipment supports.

- B. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Include design calculations for designing trapeze hangers.

HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.
- B. Pipe Welding Qualifications: Qualify procedures and operators according to 2015 ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.
- B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

2.2 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
 - 3. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
 - 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
- B. Stainless-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.
- C. Copper Pipe and Tube Hangers:
 - 1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
 - 2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel.

2.3 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly, made from structural-carbon-steel shapes, with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 PIPE-POSITIONING SYSTEMS

- A. Description: IAPMO PS 42 positioning system composed of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.5 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural-carbon-steel shapes.

2.6 MATERIALS

- A. Aluminum: ASTM B221 (ASTM B221M).
- B. Carbon Steel: ASTM A1011/A1011M.
- C. Structural Steel: ASTM A36/A36M carbon-steel plates, shapes, and bars; black and galvanized.
- D. Stainless Steel: ASTM A240/A240M.
- E. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
 2. Field fabricate from ASTM A36/A36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- D. Thermal Hanger-Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete, after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 2. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Pipe Stand Installation:
1. Pipe Stand Types, except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.
- G. Pipe-Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.
- H. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- J. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- K. Install lateral bracing with pipe hangers and supports to prevent swaying.
- L. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, 2 ½ inch and larger and at changes in direction of piping. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- N. Insulated Piping:
1. Attach clamps and spacers to piping.

- a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating Below Ambient Air Temperature: Use thermal hanger-shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
2. Install MSS SP-58, Type 39 protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
 3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
 - b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
 - c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
 - d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
 - e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.
 5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
 6. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for and **[equipment supports]**.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections, so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

- A. Touchup: Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded, shop-painted areas on miscellaneous metal are specified in Section 099113 "Exterior Painting." and Section 099123 "Interior Painting."
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.7 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports and metal framing systems and attachments for general service applications.
- F. Use copper-plated pipe hangers and **[copper] [or] [stainless-steel]** attachments for copper piping and tubing.
- G. Use padded hangers for piping that is subject to scratching.
- H. Use thermal hanger-shield inserts for insulated piping and tubing.

- I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes 2 ½ inch and larger.
 - 2. Adjustable Band Hangers (MSS Type 9): For suspension of pipes 2 inch and smaller.
 - 3. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 - 4. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
 - 5. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
- J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.
- K. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- L. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- M. Use **[powder-actuated fasteners]** [or] **[mechanical-expansion anchors]** instead of building attachments where required in concrete construction.
- N. Use pipe-positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION

SECTION 220533

PIPE FREEZE PROTECTION FOR METAL WATER PIPING

PART 1 GENERAL

1.1. SUMMARY

- A. Section includes a complete pipe freeze protection system for above ground water piping consisting of a self-regulating heating cable, connection kits, electronic controller, and installation accessories.
- B. Related Requirements
 - 1. Section 22 07 19 - Plumbing Piping Insulation
 - 2. Section 22 08 00 - Commissioning of Plumbing
 - 3. Section 22 09 00 - Instrumentation & Control for Plumbing
 - 4. Section 22 10 00 - Plumbing Piping
 - 5. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables
 - 6. Section 26 05 26 - Grounding and Bonding for Electrical Systems

1.2. REFERENCES

- A. Reference Standards
 - 1. UL515 – Electrical Resistance Heat Tracing for Commercial Applications
 - 2. IEEE 515.1-2012 Standard for the Testing, Design, Installation & Maintenance of Electric Resistance Trace Heating for Commercial Applications.
 - 3. CSA Standard C22.2 No. 130-03 Requirements for Electrical Resistance Heating Cables & Heating Device Sets
 - 4. NFPA 70 - National Electrical Code
 - 5. CSA Standard C22.1 – Canadian Electrical Code

1.3. ACTION SUBMITTALS / INFORMATIONAL SUBMITTALS

- A. Product Data
 - 1. Heating cable data sheet
 - 2. UL, CSA, FM approval certificates for freeze protection for aboveground water lines
 - 3. Pipe freeze protection design guide
 - 4. System installation and operation manual
 - 5. System installation details
 - 6. Connection kits and accessories data sheet
 - 7. Controller data sheet
 - 8. Controller wiring diagram
- B. Shop Drawings
 - 1. Plumbing Contractor is responsible for providing detailed heat tracing circuit layout drawings indicating power connections, tees, end seal, cable length and circuit cable length as well as Control panel locations as part of the submittal package. Detailed heat

tracing circuit layout drawings to be provided by Pentair Raychem Rep Emerson Swan. Please contact Mark Orgettas or Applied Products at Emerson Swan for assistance.

2. Submittals that fail to have the Product Data and Shop Drawings as stipulated will be rejected.

1.4. QUALITY ASSURANCE

- A. Source Limitations: Obtain all heat tracing system cable & components from a single source from a single manufacturer.
- B. Qualifications
 1. Manufacturers
 - a. Manufacturer to show minimum of thirty (30) years of experience in manufacturing electric self-regulating heating cables.
 - b. Manufacturer will be ISO-9001 registered.
 - c. Manufacturer to provide products consistent with UL 515, CSA 22.2 No 130-03 and IEEE 515.1 requirements.
- C. Certifications
 1. The system (heating cable, connection kits, and controller) shall be UL Listed, CSA Certified and FM Approved for freeze protection of aboveground water lines.

1.5. WARRANTY

- A. Manufacturer Warranty
 1. Pentair Thermal Building Solution warrants all goods listed below for two (2) years from date of purchase against faulty workmanship and use of defective materials when such goods are properly installed, operated, and maintained according to product documentation. See Limited Product Warranty (H57396) at www.pentairthermal.com.
 - a. Heating cables, connection kits & accessories
 - b. Thermostats, controllers, panels contactors, sensors and accessories
- B. Extended Warranty –
 1. Manufacturer shall provide ten (10) year warranty against faulty workmanship and use of defective material when such good are properly installed, operated, and maintained according to product documentation on all heat trace components. Contractor shall provide the owner an extended product warranty for the heat tracing products listed below. The contractor must complete and forward to owner the Installation, Inspection or Commissioning Record(s) located in the back of installation manual for the heat trace system being installed, and complete the online warranty registration form at www.pentairthermal.com within thirty (30) days from the date of installation, otherwise only standard limited warranty applies. See Limited Product Warranty Extension details (H57397) at www.pentairthermal.com.
 - a. Heating Cable & Components = Ten (10) Years from Date of Purchase

PART 2 PRODUCTS

2.1. HEAT TRACING SYSTEM

A. Manufacturers

1. Basis of Design Manufacturer: Subject to the compliance with requirements, provide Raychem heat tracing products of Pentair Thermal Building Solutions Please contact Mark Orgettas or Applied Products at Emerson Swan 774-257-0692

B. Materials

1. Heat Trace System shall be furnished and provided by the Plumbing Contractor.
2. Heating cables shall be Raychem model XL-Trace, self-regulating type heating cables.

- a. The Raychem XL-Trace Heating Cables shall be designed for the following voltage/wattage according to the Raychem Table below.

Insulation Thickness	Watts per FT per Pipe Diameter					
	1-4"	6"	8"	10"	12-14"	16-18"
1"	5wt/ft	8wt/ft	12wt/ft	12wt/ft	N/A	N/A
1 1/2"	5wt/ft	5wt/ft	5wt/ft	8wt/ft	8wt/ft	12wt/ft
2"	5wt/ft	5wt/ft	5wt/ft	8wt/ft	8wt/ft	12wt/ft
3"	5wt/ft	5wt/ft	5wt/ft	5wt/ft	5wt/ft	8wt/ft

- b. Refer to Raychem Table below for Maximum cable lengths allowed per circuit.

Startup Temp	CB size (A)	5XL2-CR			8XL2-CR			12XL2-CR		
		208V	240V	277V	208V	240V	277V	208V	240V	277V
40*f	15	278	283	292	206	217	229	142	145	150
	20	370	378	390	275	290	306	190	194	200
	30	470	490	530	370	390	420	285	291	300
*Maximum cable length in ft per circuit										

- c. The heating cables shall have a POLYOLEFIN outer insulating jacket with the following information clearly printed on the cable – cable model #, agency listings, meter marks & batch ID.
 - d. The heating cable shall have a modified polyolefin inner jacket and a tinned-copper braid to provide a ground path and enhance the cables ruggedness.
 - e. The heating cable shall consist of a continuous core of conductive polymer that is radiation cross-linked, extruded between two (2) 16 AWG nickel-plated copper bus wires.
 - f. The heating cable shall be UL part of a UL Listed, CSA Certified and FM Approved system.
 - g. Constant wattage cables are not acceptable.
3. Heating Cable Connection Kits
 - a. Heating cable connection kits shall be Raychem model.
 - 1) RayClic

- b. Plumbing Contractor shall provide power connections, splices/tees and end seal kits to properly connect & terminate the heating cable circuit along the specified length of above ground water piping.
 - c. All splices, tees and crosses shall be installed underneath the pipe insulation with service loops installed to allow for future service of the piping.
 - d. Connection kits shall be rated NEMA 4X to prevent water ingress and corrosion. All components shall be UV stabilized.
 - e. Connection kits shall be UL Listed, CSA Certified or FM Approved.
- 4. Attachment of Heating Cable
 - a. Attachment method of heating cable to the piping shall be Raychem model
 - 1) GT-66 – general purpose, high temperature, glass filament tape for installation @ 40°F and above. Contractor to fix the heating cable to the pipe every 12" by wrapping the GT-66 tape around the pipe & over the heating cable.
 - b. Metal cable ties are not permitted
- 5. Identification of Heating Cable System
 - a. Plumbing Contractor shall provide & install Raychem model ETL "Electric Heat Traced" labels on exterior of pipe insulation every ten (10) feet on opposite sides of the pipe for the entire length of heat traced piping.
 - b. In addition, all splices, tees, crosses and power connections shall be labeled on the exterior of the pipe insulation indicating that presence of a connection kit.
- C. Control
 - 1. Plumbing Contractor shall provide ONE of the following (1) Raychem model ECW-GF controller for each heat tracing circuit as indicated on heat tracing schedule for areas where controller needs to be mounted in OUTDOOR space exposed to the elements.
 - 2. Temperature Sensors
 - a. Contractor shall provide ONE (1) Raychem model ECW-GF SENSOR, 100 Ω, platinum 3 wire RTD for ambient temperature sensing for each ECW-GF Heat tracing controller.
 - b. Control shall use proportional ambient sensing for enhanced energy saving
 - 3. Approval
 - a. The complete heat trace system shall be listed by a NRTL for freeze protection of above ground, water piping.
 - 4. Controller to be connected to BMS system. Connection is the responsibility of controls division.

PART 3 EXECUTION

3.1. EXAMINATION

A. Verification Of Conditions

1. Prior to installation of heating cable system, verify that all piping which will be heat trace has passed all hydrostatic/pressure test and is signed off by plumbing inspector.

B. Preinstalling Testing

1. Prior to installing heating cable on the piping an insulation resistance test shall be performed by the installing contractor to ensure integrity of heating cable as describe in the installation & maintenance manual.

3.2. PREPARATION

A. Protection Of In-Place Conditions

1. All heating cable ends shall be protected from moisture ingress until cable is terminated.
2. Acceptable methods are installing RayClic-E end seals.

3.3. INSTALLATION

A. Comply with manufacturer's recommendations in the XL-Trace System Installation and Operation Manual – H58033.

B. Install electric heating cable according to the drawings and the manufacturer's instructions. The Plumbing contractor shall be responsible for providing a complete functional system, installed in accordance with applicable national and local requirements. Heat trace to be installed on all above ground copper water piping as indicated on drawings. Piping must be insulated with minimum 1" thick fiberglass insulation with moisture resistant barrier. Refer to insulation schedule for more information.

C. Interface With Other Work

1. Connection of all electrical wiring shall be according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."
2. Grounding of controller shall be according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."
3. Pipe Insulation shall be according to Section 22 07 19 "Plumbing Piping Insulation" and is required for a properly operating heat trace system.

3.4. FIELD QUALITY CONTROL

A. Field Tests And Inspections

1. The following test shall be performed after the heat cable has been installed but before the insulation and after insulating the piping. The results of both sets of test shall be recorded as detailed in the Raychem Pipe Freeze Protection Installation and Maintenance Manual and included in submittals to owner:

a. Continuity Test

- b. Insulation Resistance – 2500VDC
- c. Capacitance Check – Circuit Length Verification
- d. Power Check
- e. Ground-fault Test

B. Non-Conforming Work

- 1. Any heat tracing circuit which fails the any of the above test must be corrected prior to commissioning or startup of the system.

C. Test Records

- 1. Plumbing Contractor responsible to submit test records for manufacturer field tests for warranty compliance.

3.5. SYSTEM STARTUP

- A. Plumbing Contractor to arrange and provide for startup & commissioning of the heat tracing system and controller by manufacturers Rep Emerson Swan Co. Randolph MA. 781-986-2000.
- B. Plumbing Contractor to coordinate all controller settings with plumbing engineer prior to programming the controller.
- C. Plumbing Contractor to provide commissioning report in submittals package to owner.

END OF SECTION

SECTION 22 05 48.13

VIBRATION CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Open-spring isolators.
5. Housed-spring isolators.
6. Restrained-spring isolators.
7. Housed-restrained-spring isolators.
8. Pipe-riser resilient support.
9. Resilient pipe guides.
10. Restrained-air-spring isolators.
11. Elastomeric hangers.
12. Spring hangers.
13. Snubbers.
14. Restraints - rigid type.
15. Restraints - cable type.
16. Restraint accessories.
17. Concrete inserts.
18. Vibration isolation equipment bases.

B. Related Requirements:

1. Section 210548.13 "Vibration Controls for Fire-Suppression Piping and Equipment" for devices for fire-suppression equipment and systems.
2. Section 230548.13 "Vibration Controls for HVAC" for devices for HVAC equipment and systems.

1.3 DEFINITIONS

- A. IBC: International Building Code.
- B. OSHPD: Office of Statewide Health Planning and Development (for the State of California owned and regulated medical facilities).

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
 2. Include load rating for each wind-load-restraint fitting and assembly.
 3. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device component.
 4. Annotate to indicate application of each product submitted and compliance with requirements.
 5. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.
- B. Shop Drawings:
1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
- C. Delegated-Design Submittal:
1. Design Calculations for Vibration Isolation Devices: Calculate static and dynamic loading due to equipment weight and operating forces required to select proper vibration isolators, and to design vibration isolation bases.
 2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, and spring deflection changes. Include certification that riser system was examined for excessive stress and that none exists.
- 1.5 INFORMATIONAL SUBMITTALS
- A. Coordination Drawings: Show coordination of vibration isolation device installation for plumbing piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.
 - B. Qualification Data: For professional engineer and testing agency.
 - C. Welding certificates.
 - D. Air-Spring Mounting System Performance Certification: Include natural frequency, load, and damping test data.
 - E. Field quality-control reports.
- 1.6 CLOSEOUT SUBMITTALS
- A. Operation and Maintenance Data: For air-spring mounts to include in operation and maintenance manuals.
- 1.7 QUALITY ASSURANCE
- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct testing indicated, be an NRTL as defined by OSHA in 29 CFR 1910.7 and be acceptable to authorities having jurisdiction.

- B. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design system.
- B. Consequential Damage: Provide additional restraints for suspended fire-suppression system components or anchorage of floor-, roof-, or wall-mounted fire-suppression system components as indicated in ASCE/SEI 7-05 so that failure of a non-essential or essential fire-suppression system component will not cause failure of any other essential architectural, mechanical, or electrical building component.
- C. Fire/Smoke Resistance: All components that are not constructed of ferrous metals must have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL in accordance with ASTM E84 or UL 723, and be so labeled.
- D. Component Supports:
 - 1. Load ratings, features, and applications of all reinforcement components must be based on testing standards of a nationally recognized testing agency.
 - 2. All component support attachments must comply with force and displacement resistance requirements of ASCE/SEI 7-05 Section 13.6.

2.2 ELASTOMERIC ISOLATION PADS

- A. Elastomeric Isolation Pads:

Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. nVent (CADDY).
 - b. Vibration Eliminator Co., Inc.
 - c. Vibration Isolation.
 - d. Vibration Management Corp.
 - e. Vibration Mountings & Controls, Inc.
- 2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
- 3. Size: Factory or field cut to match requirements of supported equipment.
- 4. Minimum deflection as indicated on Drawings.
- 5. Pad Material: Oil- and water-resistant rubber.
- 6. Infused nonwoven cotton or synthetic fibers.
- 7. Load-bearing metal plates adhered to pads.
- 8. Sandwich-Core Material: [Resilient] [and] [elastomeric] <Insert compound>.

Infused nonwoven cotton or synthetic fibers.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Elastomeric Isolation Mounts.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. nVent (CADDY).
 - b. Vibration Eliminator Co., Inc.
 - c. Vibration Isolation.
 - d. Vibration Management Corp.
 - e. Vibration Mountings & Controls, Inc.
2. Mounting Plates:
 - a. Top Plate: Encapsulated steel load transfer top plates, factory drilled and threaded with threaded studs or bolts.
 - b. Baseplate: Encapsulated steel bottom plates with holes provided for anchoring to support structure.
3. Minimum deflection as indicated on Drawings.
4. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.

2.4 RESTRAINED ELASTOMERIC ISOLATION MOUNTS

A. Restrained Elastomeric Isolation Mounts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. nVent (CADDY).
 - b. Vibration Eliminator Co., Inc.
 - c. Vibration Isolation.
 - d. Vibration Management Corp.
 - e. Vibration Mountings & Controls, Inc.
2. Description: All-directional isolator with restraints containing two separate and opposing elastomeric elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 - a. Housing: Cast-ductile iron or welded steel.
 - b. Elastomeric Material: Molded, oil-resistant rubber, neoprene, or other elastomeric material.
3. Minimum deflection as indicated on Drawings.

2.5 OPEN-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. nVent (CADDY).
 - b. Vibration Eliminator Co., Inc.
 - c. Vibration Isolation.
 - d. Vibration Management Corp.
 - e. Vibration Mountings & Controls, Inc.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Baseplates: Factory-drilled steel plate for bolting to structure with an elastomeric isolator pad attached to the underside. Baseplates shall limit floor load to 500 psi.
7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
8. Minimum deflection as indicated on Drawings.

2.6 HOUSED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators in Two-Part Telescoping Housing:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. nVent (CADDY).
 - b. Vibration Eliminator Co., Inc.
 - c. Vibration Isolation.
 - d. Vibration Management Corp.
 - e. Vibration Mountings & Controls, Inc.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Minimum deflection as indicated on Drawings.
7. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi.
 - b. Top housing with [attachment and leveling bolt] [threaded mounting holes and internal leveling device] [elastomeric pad].

2.7 RESTRAINED-SPRING ISOLATORS

A. Freestanding, Laterally Stable, Open-Spring Isolators with Vertical-Limit Stop Restraint:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. nVent (CADDY).
 - b. Vibration Eliminator Co., Inc.

- c. Vibration Isolation.
 - d. Vibration Management Corp.
 - e. Vibration Mountings & Controls, Inc.
2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.
 - a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi.
 - b. Top plate with [threaded mounting holes] [elastomeric pad].
 - c. Internal leveling bolt that acts as blocking during installation.
3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
4. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
8. Minimum deflection as indicated on Drawings.

2.8 HOUSED-RESTRAINED-SPRING ISOLATORS

- A. Freestanding, Steel, Open-Spring Isolators with Vertical-Limit Stop Restraint in Two-Part Telescoping Housing:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. nVent (CADDY).
 - b. Vibration Eliminator Co., Inc.
 - c. Vibration Isolation.
 - d. Vibration Management Corp.
 - e. Vibration Mountings & Controls, Inc.
 2. Two-Part Telescoping Housing: A steel top and bottom frame separated by an elastomeric material and enclosing the spring isolators. Housings are equipped with adjustable snubbers to limit vertical movement.
 - a. Drilled base housing for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi.
 - b. Threaded top housing with adjustment bolt and cap screw to fasten and level equipment.
 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 7. Minimum deflection as indicated on Drawings.

2.9 PIPE-RISER RESILIENT SUPPORT

- A. All-Directional, Acoustical Pipe Anchor Consisting of Two Steel Tubes Separated by a Minimum 1/2-inch-Thick Neoprene:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. California Dynamics Corporation.
 - b. Kinetics Noise Control, Inc.
 - c. Mason Industries, Inc.
 - d. Vibration Eliminator Co., Inc.
 - e. Vibration Management Corp.
 2. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
 3. Maximum Load Per Support: 500 psi on isolation material providing equal isolation in all directions.
 4. Minimum deflection as indicated on Drawings.

2.10 RESILIENT PIPE GUIDES

- A. Telescopic Arrangement of Two Steel Tubes or Post and Sleeve Arrangement Separated by a Minimum 1/2-inch-Thick Neoprene:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. California Dynamics Corporation.
 - b. Kinetics Noise Control, Inc.
 - c. Mason Industries, Inc.
 - d. Vibration Eliminator Co., Inc.
 - e. Vibration Management Corp.
 - f. Vibration Mountings & Controls, Inc.
 2. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.11 RESTRAINED-AIR-SPRING ISOLATORS

- A. Freestanding, Single or Multiple, Compressed-Air Bellows with Vertical-Limit Stop Restraint:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Firestone Industrial Products Company.
 - b. Mason Industries, Inc.
 - c. nVent (CADDY).
 - d. Vibration Management Corp.
 2. Housing: Steel housing with vertical-limit stops to prevent spring extension due to weight being removed.

- a. Base with holes for bolting to structure with an elastomeric isolator pad attached to the underside. Bases shall limit floor load to 500 psi.
 - b. Top plate with [threaded mounting holes] [elastomeric pad].
 - c. Internal leveling bolt that acts as blocking during installation.
3. Restraint: Limit stop as required for equipment and authorities having jurisdiction.
 4. Minimum deflection as indicated on Drawings.
 5. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 6. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 8. Bellows Assembly: Upper and lower powder-coated steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows or similar elastomeric material.
 9. Maximum Natural Frequency: 3 Hz.
 10. Operating Pressure Range: 25 to 100 psi.
 11. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
 12. Automatic leveling valve.

2.12 ELASTOMERIC HANGERS

A. Elastomeric Mount in a Steel Frame with Upper and Lower Steel Hanger Rods:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. nVent (CADDY).
 - b. Vibration Eliminator Co., Inc.
 - c. Vibration Isolation.
 - d. Vibration Management Corp.
 - e. Vibration Mountings & Controls, Inc.
2. Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
3. Damping Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel-to-steel contact.
4. Minimum deflection as indicated on Drawings.

2.13 SPRING HANGERS

A. Combination Coil-Spring and Elastomeric-Insert Hanger with Spring and Insert in Compression:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Novia; A Division of C&P.
 - b. nVent (CADDY).
 - c. Vibration Eliminator Co., Inc.
 - d. Vibration Isolation.
 - e. Vibration Management Corp.
 - f. Vibration Mountings & Controls, Inc.

2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Minimum deflection as indicated on Drawings.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
8. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
9. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
10. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.14 SNUBBERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Kinetics Noise Control, Inc.
 2. Mason Industries, Inc.
 3. nVent (CADDY).
 4. Vibration Management Corp.
 5. Vibration Mountings & Controls, Inc.
- B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
1. Post-Installed Concrete Anchor Bolts: Secure to concrete surface with post-installed concrete anchors. Anchors to be prequalified in accordance with ACI 355.2 testing and designated in accordance with ACI 318-14 Ch. 17 for 2015 or 2018 IBC
 2. Preset Concrete Inserts: Prequalified in accordance with ICC-ES AC446 testing.
 3. Anchors in Masonry: Design in accordance with TMS 402.
 4. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
 5. Resilient Cushion: Maximum 1/4-inch air gap, and minimum 1/4 inch thick.

2.15 RESTRAINTS - RIGID TYPE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Atkore International (Unistrut).
 2. California Dynamics Corporation.
 3. Eaton (B-line).
 4. Hilti, Inc.
 5. Isolation Technology, Inc.
 6. nVent (CADDY).
 7. TOLCO.
 8. Vibration Mountings & Controls, Inc.

- B. Description: Shop- or field-fabricated bracing assembly made of AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe as per NFPA 13, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.16 RESTRAINTS - CABLE TYPE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton (B-line).
 - 2. Loos & Co.
 - 3. nVent (CADDY).
 - 4. Vibration Mountings & Controls, Inc.
- B. Restraint Cables: A492 stainless steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with fittings attached by means of poured socket, swaged socket, or mechanical (Flemish eye) loop.
- C. Restraint cable assembly and cable fittings must comply with ASCE/SEI 19-10. All cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

2.17 RESTRAINT ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Atkore International (Unistrut).
 - 2. Eaton (B-line).
 - 3. Hilti, Inc.
 - 4. Loos & Co.
 - 5. Mason Industries, Inc.
 - 6. nVent (CADDY).
 - 7. TOLCO.
- B. Hanger-Rod Stiffener: [Steel tube or steel slotted-support-system sleeve with internally bolted connections] [Reinforcing steel angle clamped] to hanger rod.
- C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings and restraint cables.
- D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings and matched to type and size of anchor bolts and studs.
- E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings and matched to type and size of attachment devices used.
- F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.18 CONCRETE INSERTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Atkore International (Unistrut).
 - 2. Eaton (B-line).
 - 3. Hilti, Inc.
 - 4. Mason Industries, Inc.
 - 5. Powers Fasteners.
 - 6. Simpson Strong-Tie Co., Inc.
- B. Provide preset concrete inserts that are prequalified in accordance with ICC-ES AC466 testing.
- C. Comply with ANSI/MSS SP-58.

2.19 VIBRATION ISOLATION EQUIPMENT BASES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. California Dynamics Corporation.
 - 2. Kinetics Noise Control, Inc.
 - 3. Mason Industries, Inc.
 - 4. Novia; A Division of C&P.
 - 5. nVent (CADDY).
 - 6. Vibration Eliminator Co., Inc.
 - 7. Vibration Isolation.
 - 8. Vibration Management Corp.
 - 9. Vibration Mountings & Controls, Inc.
- B. Steel Rails: Factory-fabricated, welded, structural-steel rails.
 - 1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide rails.
 - a. Include supports for suction and discharge elbows for pumps.
 - 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Rails shall have shape to accommodate supported equipment.
 - 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
- C. Steel Bases: Factory-fabricated, welded, structural-steel bases and rails.
 - 1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases shall have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
- D. Concrete Inertia Base: Factory-fabricated or field-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - a. Include supports for suction and discharge elbows for pumps.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases shall have shape to accommodate supported equipment.
 3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
 4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application.
- B. Hanger-Rod Stiffeners: Install where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to wind load forces.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength is adequate to carry static forces within specified loading limits.

3.3 INSTALLATION OF VIBRATION-CONTROL DEVICES

- A. Provide vibration-control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Device Schedules, where indicated on Drawings, or where the Specifications indicate they are to be installed on specific equipment and systems.

- B. Provide wind-load control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Device Schedules, where indicated on Drawings, where the Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.
- C. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."
- D. Installation of vibration isolators must not cause any stresses, misalignment or change of position of equipment or piping.
- E. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- F. Equipment Restraints:
 - 1. Install snubbers on plumbing equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
 - 2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
- G. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.
 - 2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
 - 3. Brace a change of direction longer than 12 feet.
- H. Install wind-load-restraint cables so they do not bend across edges of adjacent equipment or building structure.
- I. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- J. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- K. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- L. Post-Installed Concrete Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify Project structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Mechanical-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL MOTION

- A. Provide flexible connections in piping systems where they cross structural joints and other point where differential movement may occur. Provide adequate flexibility to accommodate differential movement as determined in accordance with ASCE/SEI 7. Comply with requirements in Section 221116 "Domestic Water Piping" and Section 221119 "Domestic Water Piping Specialties" for piping flexible connections.

3.5 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT BASES

- A. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."
- B. Coordinate dimensions of steel equipment rails, bases, and concrete inertia bases, with requirements of isolated equipment specified in this and other Sections. Where dimensions of base are indicated on Drawings, they may require adjustment to accommodate actual isolated equipment.

3.6 ADJUSTING

- A. Adjust isolators after system is at operating weight.
- B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

3.7 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Tests and Inspections:
 1. Perform tests and inspections.
 2. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 3. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.

4. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 5. Test no fewer than four of each type and size of installed anchors and fasteners selected by Architect.
 6. Test to 90 percent of rated proof load of device.
 7. Measure isolator restraint clearance.
 8. Measure isolator deflection.
 9. Verify snubber minimum clearances.
 10. Test and adjust restrained-air-spring isolator controls and safeties.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Units will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION

SECTION 22 05 53

IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Pipe labels.
 - 4. Stencils.
 - 5. Valve tags.
 - 6. Warning tags.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- D. Valve numbering scheme.
- E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Plastic Labels for Equipment:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brimar Industries, Inc.
 - b. Seton Identification Products; a Brady Corporation company.
 - 2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, [1/16 inch] [1/8 inch] <Insert dimension> thick and having predrilled holes for attachment hardware.

3. Letter Color: Black.
 4. Background Color: White.
 5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
 6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 7. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Label Content: Include equipment's Drawing designation or unique equipment number, drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.
- C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Brady Corporation.
 2. Brimar Industries, Inc.
 3. LEM Products Inc.
 4. Seton Identification Products; a Brady Corporation company.
- B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, [1/16 inch] [1/8 inch] <Insert dimension> thick and having predrilled holes for attachment hardware.
- C. Letter Color: White.
- D. Background Color: Red.
- E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. LEM Products Inc.
 - 2. Seton Identification Products; a Brady Corporation company.
- B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to [partially cover] [cover full] circumference of pipe and to attach to pipe without fasteners or adhesive.
- D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size At least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.

2.4 VALVE TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady Corporation.
 - 2. Brimar Industries, Inc.
 - 3. LEM Products Inc.
 - 4. Seton Identification Products; a Brady Corporation company.
- B. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
 - 1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. Fasteners: Brass wire-link chain.
- C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - 1. Valve-tag schedule shall be included in operation and maintenance data.

2.5 WARNING TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Brady Corporation.
 2. Brimar Industries, Inc.
 3. LEM Products Inc.
 4. Seton Identification Products; a Brady Corporation company.
- B. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.
1. Size: Approximately 4 by 7 inches.
 2. Fasteners: Brass grommet and wire.
 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 4. Color: Safety yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

- A. Piping Color Coding: Painting of piping is specified in [Section 099123 "Interior Painting."] [Section 099600 "High-Performance Coatings."]
- B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, with painted, color-coded bands or rectangles on each piping system.
1. Identification Paint: Use for contrasting background.
 2. Stencil Paint: Use for pipe marking.
- C. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 5. Near major equipment items and other points of origination and termination.
 6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- D. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- E. Pipe Label Color Schedule:
1. Low-Pressure Compressed Air Piping:
 - a. Background: [Safety blue] <Insert color>.
 - b. Letter Colors: [White] <Insert color>.
 2. High-Pressure Compressed Air Piping:
 - a. Background: [Safety blue] <Insert color>.
 - b. Letter Colors: [White] <Insert color>.
 3. Domestic Water Piping
 - a. Background: Safety green.
 - b. Letter Colors: White.
 4. [Sanitary Waste] [and] [Storm Drainage] Piping:
 - a. Background Color: Safety black.
 - b. Letter Color: White.

3.5 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
1. Valve-Tag Size and Shape:
 - a. Cold Water: 2 inches, round.
 - b. Hot Water: 2 inches, round <Insert shape>.
 - c. Low-Pressure Compressed Air: 2 inches, round.
 - d. High-Pressure Compressed Air: 2 inches, round.
 2. Valve-Tag Colors:

- a. Cold Water: Safety green.
- b. Hot Water: Safety green.
- c. Low-Pressure Compressed Air: Safety blue.
- d. High-Pressure Compressed Air: Safety blue.

3. Letter Colors:

- a. Cold Water: White.
- b. Hot Water: White.
- c. Low-Pressure Compressed Air: White.
- d. High-Pressure Compressed Air: White.

3.6 WARNING-TAG INSTALLATION

- A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION

SECTION 22 07 19

PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes insulating the following plumbing piping services:

1. Domestic cold-water piping.
2. Domestic hot-water piping.
3. Domestic recirculating hot-water piping.
4. Sanitary waste piping exposed to freezing conditions.
5. Primary and Overflow storm piping.

- B. Related Sections:

1. Section 220716 "Plumbing Equipment Insulation" for equipment insulation.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 2. Detail attachment and covering of heat tracing inside insulation.
 3. Detail insulation application at pipe expansion joints for each type of insulation.
 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 5. Detail removable insulation at piping specialties, equipment connections, and access panels.
 6. Detail application of field-applied jackets.
 7. Detail application at linkages of control devices.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

- C. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less and smoke-developed index of 150 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," and articles for where insulating materials shall be applied.

- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come into contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Comply with ASTM C552.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Pittsburgh Corning Corporation.
 - 2. Preformed Pipe Insulation: Type II, Class 2, with factory-applied jacket.
 - 3. Factory fabricate shapes in accordance with ASTM C450 and ASTM C585.
 - 4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 5. Preformed Pipe Insulation: Type I, Grade A with factory-applied ASJ.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber Insulating Cement: Comply with ASTM C195.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Ramco Insulation, Inc.
- B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C196.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Ramco Insulation, Inc.
- C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Ramco Insulation, Inc.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

- B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Foster Brand; H. B. Fuller Construction Products.
- C. PVC Jacket Adhesive: Compatible with PVC jacket.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Dow Consumer Solutions.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. P.I.C. Plastics, Inc.
 - d. Speedline Corporation.

2.4 LAGGING ADHESIVES

- A. Adhesives shall comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.

2.5 SEALANTS

- A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.
 - 1. Service Temperature Range: Minus 40 to plus 250 deg F.
 - 2. Color: White.
 - 3. FACTORY-APPLIED JACKETS
- B. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - 1. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
 - 1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range of between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
 - 2. Carbon Steel: Coat carbon steel operating at a service temperature of between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of pipe system, as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.

- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
 - 3. Install insert materials and insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at 4 inches o.c.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 25 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.
- P. For above-ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Cleanouts.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 - 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
 - 1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
 - 1. Pipe: Install insulation continuously through floor penetrations.
 - 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 2. Insulate pipe elbows using preformed fitting insulation made from same material and density as that of adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Insulate tee fittings with preformed fitting insulation of same material and thickness as that used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using preformed fitting insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 5. Insulate strainers using preformed fitting insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers, so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges, mechanical couplings, and unions, using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as that of adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in

- place with stainless steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
 5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive, as recommended by insulation material manufacturer, and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as that of pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as that of straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.7 FIELD QUALITY CONTROL

- A. Owner will engage a qualified testing agency to perform tests and inspections.
- B. Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections[with the assistance of a factory-authorized service representative].
- E. Tests and Inspections: Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to **three** locations of straight pipe, **three** locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
- F. All insulation applications will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports.

3.8 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.9 INDOOR PIPING INSULATION SCHEDULE

- A. Domestic Cold Water:
 - 1. 1 inch and Smaller: Insulation shall be the following:
 - a. Mineral Fiber: 1/2 inch thick.
 - 2. 1 ¼ inch and Larger: Insulation shall be the following:
 - a. Mineral Fiber: 1 inch thick.
- B. Domestic Hot and Recirculated Hot Water:
 - 1. 1 ¼ inch and Smaller: Insulation shall be the following:

- a. Mineral Fiber: 1 inch thick.
- 2. 1 ½ inch and Larger: Insulation shall be the following:
 - a. Mineral Fiber: 1-1/2 inches thick.
- C. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
 - 1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 1/2 inch thick.
- D. Sanitary Waste and Storm Piping Where Heat Tracing Is Installed:
 - 1. All Pipe Sizes: Insulation shall be the following:
 - a. Mineral Fiber: 1 inch thick.
- E. Floor Drains, Traps, and Sanitary Drain Piping within 10 feet of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F:
 - 1. All Pipe Sizes: Insulation shall be the following:
 - a. Mineral Fiber: 1 inch thick.
- F. Hot Service Drains:
 - 1. All Pipe Sizes: Insulation shall be the following:
 - a. Mineral Fiber: 1 inch thick.

END OF SECTION

SECTION 220800

PLUMBING SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 RELATED SECTIONS

- A. Division 22 – Plumbing
- B. Section 019113 – General Commissioning Requirements

1.3 REQUIRMENTS

- A. The Commissioning process requires the participation of Division 22, Plumbing, to ensure that all systems fulfill the functional and pre-functional requirements set forth in these construction documents. The general commissioning requirements and coordination are detailed in Section 019113. Division 22, Plumbing, shall fulfill commissioning responsibilities assigned to division 22 in accordance with Section 019113.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PRE-FUNCTIONAL CHECKLISTS

- A. Pre-functional checklists assist in the process to document that the equipment and systems are installed properly.
- B. The contractor will be provided with construction checklists from the CA for completion. The contractor shall complete the checklists as provide the CA with completed copies in accordance with 019113.
- C. See attached for a sample pre-functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.2 FUNCTIONAL PERFORMANCE TESTING

- A. Intent of functional performance testing is to prove thru functional test procedures proper system operation.

- B. The contractor will be provided with functional performance test procedures to perform while CA witnesses. The contractor shall perform functional tests in accordance with 019113.
- C. See attached for a sample functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.3 PREFUNCTIONAL CHECKLISTS AND FUNCTIONAL PREFORMANCE TESTING

- A. Pre-Functional Checklists and Functional performance testing procedures will be performed on the following system types. (Pre Functional and Functional performance testing requirements are in addition to and do not replace any testing required elsewhere in Division 22 or by applicable codes.) Equipment specifically marked as such below shall be provided with start-up of equipment by factory-authorized service representative.

- 1. Domestic Hot Water Heater and Recirculation System

- a. Provide documentation for factory authorized start-up on water heaters.
 - b. Provide sign off and/or documentation of mixing valve setup and recirculation system balancing as per the requirements of the contract documents and or manufacturer's instructions.
 - c. Provide sign off and/or documentation of system flushing as per the requirements of the contract documents.

- 2. Sinks and Lavatories

- 3. Water Closets

3.4 SAMPLE CHECKLISTS

- A. See Attached.

END OF SECTION

SAMPLE ONLY

Contractor Checklist and Functional Test Procedures

DOMESTIC WATER HEATER AND RECIRCULATION SYSTEM

1. Participants

Discipline	Name	Company
CxA		
Mechanical		
Controls		
TAB		
Plumbing		
Electrical		
Date Returned to CxA		

2. Prerequisite Checklist

Check	Description
<input type="checkbox"/>	The above equipment and systems integral to them are complete and ready for functional testing.
<input type="checkbox"/>	All control system functions for this and all interlocking systems are programmed and operable per contract documents, including final setpoints and schedules with debugging, loop tuning and sensor calibrations completed.
<input type="checkbox"/>	Test and balance completed and approved for the hydronic systems and terminal units connected
<input type="checkbox"/>	All A/E punchlist items for this equipment corrected.
<input type="checkbox"/>	Safeties and operating ranges reviewed.
<input type="checkbox"/>	Schedules and reviewed <ul style="list-style-type: none">This checklist does not take the place of the manufacturer's recommended checkout and startup procedures.Items that do not apply shall be noted with the reasons on this form (N/A = not applicable, BO = by others).Contractor's assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off.

3. Installation Checks

Check	Domestic HW System
General Installation	
Permanent labels affixed	<input type="checkbox"/>
Casing condition good: no dents	<input type="checkbox"/>
Maintenance access acceptable for unit and components valve has been installed where it can be easily, cleaned, adjusted, etc.	<input type="checkbox"/>
Concrete pad provided	<input type="checkbox"/>
Instrumentation installed according to specification (thermometers, pressure gages, flow meters, etc.)	<input type="checkbox"/>
Clean up of equipment completed per contract documents	<input type="checkbox"/>
Main gas, pilot gas pressure regulators, and high and low pressure switches are vented to the outdoors	<input type="checkbox"/>
Water heater is ASME rated	<input type="checkbox"/>
Piping arrangement installed per the contract documents	<input type="checkbox"/>
Installation of combustion air fan and associated motorized damper	<input type="checkbox"/>
Flue pipe installed as per the contract documents	<input type="checkbox"/>
Valves and Piping	
Pipe fittings complete and pipes properly supported	<input type="checkbox"/>
Pipes properly labeled	<input type="checkbox"/>
Pipes properly insulated	<input type="checkbox"/>
Relief valve on water heater properly piped	<input type="checkbox"/>
Valves properly labeled	<input type="checkbox"/>
Valves installed in proper direction	<input type="checkbox"/>
Piping system properly flushed	<input type="checkbox"/>
No leaking apparent around fittings	<input type="checkbox"/>
Cold water make-up isolation valve	<input type="checkbox"/>
Isolation valves installed per drawings	<input type="checkbox"/>
Water heater drain valve	<input type="checkbox"/>
ASME Pressure relief valve	<input type="checkbox"/>
Re-circulation line connection to cold water make-up	<input type="checkbox"/>
Gas connection with plug valve	<input type="checkbox"/>
Gas train to water heater	<input type="checkbox"/>
Sensors calibrated	<input type="checkbox"/>
Electrical and Controls	
Power disconnects in place and labeled	<input type="checkbox"/>
All electric connections tight	<input type="checkbox"/>
Safeties in place and operable	<input type="checkbox"/>
Misc.	
Aquastat installed on recirculation pumps	<input type="checkbox"/>
Recirc pumps in place and service switches in place and labeled	<input type="checkbox"/>

4. Functional Testing Record

Test #	Mode ID	Test Procedure (including special conditions)	Expected Response	Pass Y/N	Note
1	Manufacturers Startup	Procedures performed as per manufacturers requirements	Startup Report attached		
2	Operating con- trol	Set operating controller above setpoints degrees F.	Burner turns on		
3	Operating con- trol	Set operating controller below setpoints degrees F.	Burner turns off		
4	Recirc Pumps	Simulate a call for the domestic water heater	The circ pumps operate as needed. Ensure also that the disconnect switches associated will turn the pump on/off for service.		
5	Set- ting/balancing the Mixing Valve	See methods below	As listed below		

☐ ***Balancing Procedures have been followed as per manufacturer recommendations per specific manufacturer.***

SECTION 221116

DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Under-building-slab and aboveground domestic water pipes, tubes, and fittings inside buildings.
 - 2. Encasement for piping.

1.3 ACTION SUBMITTALS

- A. Product Data: For transition fittings and dielectric fittings.

1.4 INFORMATIONAL SUBMITTALS

- A. System purging and disinfecting activities report.
- B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.
- B. Potable-water piping and components shall comply with NSF 14 and NSF 61 Annex G. Plastic piping components shall be marked with "NSF-pw."

2.2 COPPER TUBE AND FITTINGS

- A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.
- B. Soft Copper Tube: ASTM B 88, Type K and ASTM B 88, Type L water tube, annealed temper.
- C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
- D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

- E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
- F. Copper Unions:
 - 1. MSS SP-123.
 - 2. Cast-copper-alloy, hexagonal-stock body.
 - 3. Ball-and-socket, metal-to-metal seating surfaces.
 - 4. Solder-joint or threaded ends.
- G. Copper Pressure-Seal-Joint Fittings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Elkhart Products Corporation.
 - b. NIBCO INC.
 - c. Viega LLC.
 - 2. Fittings for NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber, O-ring seal in each end and shall conform to ASME B16.51, ICC LC 1002, IAPMO PS 117. Fittings must have Smart Connect Technology or leak detection features.
 - 3. Fittings for NPS 2-1/2 to NPS 4: Cast-bronze or wrought-copper fitting with EPDM-rubber, O-ring seal in each end and shall conform to ASME B16.51, ICC LC 1002, IAPMO PS 117. Fittings must have Smart Connect Technology or leak detection features.
- H. Appurtenances for Grooved-End Copper Tubing:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International.
 - b. Grinnell Mechanical Products.
 - c. Shurjoint Piping Products.
 - d. Victaulic Company.
 - 2. Bronze Fittings for Grooved-End, Copper Tubing: ASTM B 75 copper tube or ASTM B 584 bronze castings.
 - 3. Mechanical Couplings for Grooved-End Copper Tubing:
 - a. Copper-tube dimensions and design similar to AWWA C606.
 - b. Ferrous housing sections.
 - c. EPDM-rubber gaskets suitable for hot and cold water.
 - d. Bolts and nuts.
 - e. Minimum Pressure Rating: 300 psig.

2.3 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials:
 - 1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
 - 2. Full-face or ring type unless otherwise indicated.

- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- C. Solder Filler Metals: ASTM B 32, lead-free alloys.
- D. Flux: ASTM B 813, water flushable.
- E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
- F. Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.4 TRANSITION FITTINGS

- A. General Requirements:
 - 1. Same size as pipes to be joined.
 - 2. Pressure rating at least equal to pipes to be joined.
 - 3. End connections compatible with pipes to be joined.
- B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

2.5 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
 - Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Watts; a Watts Water Technologies company.
 - b. Wilkins.
 - c. Zurn Industries, LLC.
 - 2. Standard: ASSE 1079.
 - 3. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Flanges:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Watts; a Watts Water Technologies company.
 - b. Wilkins.
 - c. Zurn Industries, LLC.
 - 2. Standard: ASSE 1079.
 - 3. Factory-fabricated, bolted, companion-flange assembly.

4. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Calpico, Inc.
 - b. Central Plastics Company.
 - c. Pipeline Seal and Insulator, Inc.
2. Nonconducting materials for field assembly of companion flanges.
3. Gasket: Neoprene or phenolic.
4. Bolt Sleeves: Phenolic or polyethylene.
5. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Grinnell Mechanical Products.
 - b. Victaulic Company.
2. Standard: IAPMO PS 66.
3. Electroplated steel nipple complying with ASTM F 1545.
4. End Connections: Male threaded or grooved.
5. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."
- C. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance.
- D. Install shutoff valve immediately upstream of each dielectric fitting.
- E. Install domestic water piping level and plumb.

- F. Rough-in domestic water piping for water-meter installation according to utility company's requirements.
- G. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- H. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- I. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.
- J. Install piping to permit valve servicing.
- K. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.
- L. Install piping free of sags and bends.
- M. Install fittings for changes in direction and branch connections.
- N. Install PEX piping with loop at each change of direction of more than 90 degrees.
- O. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
- P. Install pressure gauges on suction and discharge piping for each plumbing pump and packaged booster pump.
- Q. Install thermometers on outlet piping from each water heater.
- R. Install sleeves for piping penetrations of walls, ceilings, and floors.
- S. Install sleeve seals for piping penetrations of concrete walls and slabs.
- T. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.3 JOINT CONSTRUCTION

- A. A. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.
 - 1. Mark proper insertion depth prior to making connection.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

- D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
 - E. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.
 - F. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."
 - G. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.
 - H. Joint Construction for Grooved-End Copper Tubing: Make joints according to AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.
 - I. Joint Construction for Grooved-End, Ductile-Iron Piping: Make joints according to AWWA C606. Cut round-bottom grooves in ends of pipe at gasket-seat dimension required for specified (flexible or rigid) joint. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket with keys seated in piping grooves. Install and tighten housing bolts.
 - J. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.
 - K. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.
- 3.4 TRANSITION FITTING INSTALLATION
- A. Install transition couplings at joints of dissimilar piping.
 - B. Transition Fittings in Underground Domestic Water Piping:
 - 1. Fittings for NPS 1-1/2 and Smaller: Fitting-type coupling.
 - 2. Fittings for NPS 2 and Larger: Sleeve-type coupling.
 - C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings or unions.
- 3.5 DIELECTRIC FITTING INSTALLATION
- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
 - B. Dielectric Fittings for NPS 6 and Larger: Use dielectric flange kits.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hanger, support products, and installation in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Vertical Piping: MSS Type 8 or 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
 - 3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - 4. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Support vertical piping and tubing at base and at each floor.
- C. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.
- D. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
 - 2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
 - 3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
 - 4. NPS 2-1/2: 108 inches with 1/2-inch rod.
 - 5. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
 - 6. NPS 6: 10 feet with 5/8-inch rod.
 - 7. NPS 8: 10 feet with 3/4-inch rod.
- E. Install supports for vertical copper tubing every 10 feet.
- F. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/4 and Smaller: 84 inches with 3/8-inch rod.
 - 2. NPS 1-1/2: 108 inches with 3/8-inch rod.
 - 3. NPS 2: 10 feet with 3/8-inch rod.
 - 4. NPS 2-1/2: 11 feet with 1/2-inch rod.
 - 5. NPS 3 and NPS 3-1/2: 12 feet with 1/2-inch rod.
 - 6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
 - 7. NPS 6: 12 feet with 3/4-inch rod.
 - 8. NPS 8 to NPS 12: 12 feet with 7/8-inch rod.
- G. Install supports for vertical stainless-steel piping every 15 feet.
- H. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.

- B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.
- C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.
- D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
 - 1. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
 - 2. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
 - 3. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.8 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing Piping and Equipment."
- B. Label pressure piping with system operating pressure.

3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Piping Inspections:
 - a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
 - b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
 - 1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
 - 2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.
 - c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections, and arrange for reinspection.
 - d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
 - 2. Piping Tests:
 - a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
 - b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in

- segments, submit a separate report for each test, complete with diagram of portion of piping tested.
- c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
- 1) Press-connect fittings: after installation a "two step test" shall be followed. Pressurize the system with application appropriate test medium, water between 15 and 85 psi, or air/dry nitrogen between .5 and 45 psi. Check the pressure gauge for pressure loss. If the system does not hold pressure, walk the system, and check for unpressed fittings. Should any unpressed fittings be identified following test, ensure the tube is fully inserted into the fitting and properly marked prior to pressing the joint. After appropriate repairs have been made, retest the system per local code and specification requirements, not to exceed 600 psi with water or, 200 psi when using air.
- e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
 - f. Prepare reports for tests and for corrective action required.
- B. Domestic water piping will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.
- 3.10 ADJUSTING
- A. Perform the following adjustments before operation:
- 1. Close drain valves, hydrants, and hose bibbs.
 - 2. Open shutoff valves to fully open position.
 - 3. Open throttling valves to proper setting.
 - 4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
 - a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
 - b. Adjust calibrated balancing valves to flows indicated.
 - c. Provide balancing report.
 - 5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
 - 6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
 - 7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
 - 8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.11 CLEANING

- A. Clean and disinfect potable domestic water piping as follows:
 - 1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
 - 2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Fill and isolate system according to either of the following:
 - 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
 - 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
 - c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
 - d. Repeat procedures if biological examination shows contamination.
 - e. Submit water samples in sterile bottles to authorities having jurisdiction.
- B. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.
- C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.12 PIPING SCHEDULE

- A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
- B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.
- C. Aboveground domestic water piping, NPS 4 and smaller, shall be one of the following:
 - 1. Hard copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and soldered joints.
 - 2. Hard copper tube, ASTM B 88, Type L; copper pressure-seal-joint fittings; and pressure-sealed joints.

3.13 VALVE SCHEDULE

- A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
 - 1. Shutoff Duty: Use ball valves for piping NPS 2 and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 and larger.

2. Hot-Water Circulation Piping, Balancing Duty: Memory-stop balancing valves.
 3. Drain Duty: Hose-end drain valves.
- B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

END OF SECTION

SECTION 22 11 23

NATURAL GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Pipes, tubes, and fittings.
 - 2. Piping specialties.
 - 3. Piping and tubing joining materials.
 - 4. Valves.
 - 5. Pressure regulators.

1.3 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.4 PERFORMANCE REQUIREMENTS

- A. Minimum Operating-Pressure Ratings:
 - 1. Piping and Valves: 100 psig minimum unless otherwise indicated.
 - 2. Service Regulators: 100 psig minimum unless otherwise indicated.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Piping specialties.
 - 2. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
 - 3. Pressure regulators. Indicate pressure ratings and capacities.
 - 4. Dielectric fittings.

- B. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
 - 1. Shop Drawing Scale: 1/4 inch per foot.
 - 2. Detail mounting, supports, and valve arrangements for pressure regulator assembly.

1.6 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.
- B. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.
- C. Qualification Data: For qualified professional engineer.
- D. Welding certificates.
- E. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For gas valves pressure regulators and service meters to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

- A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.
- B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating and protect from direct sunlight.

- D. Protect stored PE pipes and valves from direct sunlight.

1.10 PROJECT CONDITIONS

- A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.
- B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:
 - 1. Notify Construction Manager no fewer than two days in advance of proposed interruption of natural-gas service.
 - 2. Do not proceed with interruption of natural-gas service without Owner's written permission.

1.11 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
 - 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 - 2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
 - 3. Steel Press-Connect Fittings: CSA LC-4, 125-psig pressure rating.
 - a. Press Ends: Unpressed fitting identification feature to the fitting wall.
 - b. Pipe Threads: ASME B1.20.1.
 - c. Sealing Elements: HNBR.
 - d. Tools: Manufacturer's recommended tools, jaws, rings, and actuators.
 - 4. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
 - 5. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - a. Material Group: 1.1.
 - b. End Connections: Threaded or butt welding to match pipe.
 - c. Lapped Face: Not permitted underground.
 - d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig.
6. End Fittings: Zinc-coated steel.
7. Threaded Ends: Comply with ASME B1.20.1.
8. Maximum Length: 72 inches

B. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

C. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

D. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 40-mesh startup strainer and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig.

E. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.3 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

- C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.4 MANUAL GAS SHUTOFF VALVES

- A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.
- B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
 - 1. CWP Rating: 125 psig.
 - 2. Threaded Ends: Comply with ASME B1.20.1.
 - 3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
 - 4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - 5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
 - 6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.
- C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.
 - 1. CWP Rating: 125 psig.
 - 2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
 - 3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - 4. Service Mark: Initials "WOG" shall be permanently marked on valve body.
- D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. BrassCraft Manufacturing Co.; a Masco company.
 - c. Conbraco Industries, Inc.
 - d. Lyall, R. W. & Company, Inc.
 - e. Perfection Corporation.
 - 2. Body: Bronze, complying with ASTM B 584.
 - 3. Ball: Chrome-plated bronze.
 - 4. Stem: Bronze; blowout proof.
 - 5. Seats: Reinforced TFE; blowout proof.
 - 6. Packing: Threaded-body packnut design with adjustable-stem packing.
 - 7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - 8. CWP Rating: 600 psig.

9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Bronze Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Lee Brass Company.
2. Body: Bronze, complying with ASTM B 584.
3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig.
7. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.5 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Line Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Actaris.
 - b. American Meter Company.
 - c. Eclipse Innovative Thermal Technologies.
 - d. Fisher Control Valves & Instruments; a brand of Emerson Process Management.
 - e. Invensys.
 - f. Itron Gas.
 - g. Maxitrol Company.
 - h. Richards Industries.
2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.

8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 2 psig.

C. Appliance Pressure Regulators: Comply with ANSI Z21.18.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Canadian Meter Company Inc.
 - b. Eaton.
 - c. Harper Wyman Co.
 - d. Maxitrol Company.
 - e. SCP, Inc.
2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure: 2 psig.

2.6 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Capitol Manufacturing Company.
 - c. Central Plastics Company.
 - d. HART Industrial Unions, LLC.
 - e. Jomar Valve.
 - f. Matco-Norca.
 - g. Watts; a Watts Water Technologies company.
 - h. Wilkins.
 - i. Zurn Industries, LLC.
 2. Description:

- a. Standard: ASSE 1079.
- b. Pressure Rating: 125 psig minimum at 180 deg F.
- c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Matco-Norca.
 - d. Watts; a Watts Water Technologies company.
 - e. Wilkins.
- 2. Description:
 - a. Standard: ASSE 1079.
 - b. Factory-fabricated, bolted, companion-flange assembly.
 - c. Pressure Rating: 125 psig minimum at 180 deg F.
 - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Central Plastics Company.
 - d. Pipeline Seal and Insulator, Inc.
- 2. Description:
 - a. Nonconducting materials for field assembly of companion flanges.
 - b. Pressure Rating: 150 psig.
 - c. Gasket: Neoprene or phenolic.
 - d. Bolt Sleeves: Phenolic or polyethylene.
 - e. Washers: Phenolic with steel backing washers.

2.7 LABELING AND IDENTIFYING

- A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.
- B. Elevated pressure gas line shall be labeled as required by Massachusetts gas codes.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Close equipment shutoff valves before turning off natural gas to premises or piping section.
- B. Inspect natural-gas piping according to NFPA 54 to determine that natural-gas utilization devices are turned off in piping section affected.
- C. Comply with NFPA 54 requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

- A. Comply with NFPA 54 for installation and purging of natural-gas piping.
- B. Install underground, natural-gas piping buried at least 36 inches below finished grade. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.
 - 1. If natural-gas piping is installed less than 36 inches below finished grade, install it in containment conduit.
- C. Steel Piping with Protective Coating:
 - 1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
 - 2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
 - 3. Replace pipe having damaged PE coating with new pipe.
- D. Install fittings for changes in direction and branch connections.
- E. Install pressure gage upstream and downstream from each service regulator.

3.4 INDOOR PIPING INSTALLATION

- A. Comply with NFPA 54 for installation and purging of natural-gas piping.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Locate valves for easy access.
- H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and branch connections.
- K. Verify final equipment locations for roughing-in.
- L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
- M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, unless indicated to be exposed to view.
- P. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
 - 1. Exception: Tubing passing through partitions or walls does not require striker barriers.
 - 2. Prohibited Locations:
 - a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys, or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
 - b. Do not install natural-gas piping in solid walls or partitions.
- Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

- R. Connect branch piping from top or side of horizontal piping.
- S. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- T. Do not use natural-gas piping as grounding electrode.
- U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
- V. Install pressure gage upstream and downstream from each line regulator.
- W. Install sleeves for piping penetrations of walls, ceilings, and floors.
- X. Install sleeve seals for piping penetrations of concrete walls and slabs.
- Y. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.5 VALVE INSTALLATION

- A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.
- B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

3.6 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints:
 - 1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
 - 2. Cut threads full and clean using sharp dies.
 - 3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
 - 4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
 - 5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. Welded Joints:
 - 1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
 - 2. Bevel plain ends of steel pipe.
 - 3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.
- E. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

- F. Press Joints: Press joints shall be installed with the most current manufacturers installation instructions.

3.7 HANGER AND SUPPORT INSTALLATION

- A. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
 - 1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
 - 2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
 - 3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
 - 4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
 - 5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

3.8 CONNECTIONS

- A. Connect to utility's gas main according to utility's procedures and requirements.
- B. Install natural-gas piping electrically continuous and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.
- C. Install piping adjacent to appliances to allow service and maintenance of appliances.
- D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
- E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.9 LABELING AND IDENTIFYING

- A. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.10 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Test, inspect, and purge natural gas according to NFPA 54 and authorities having jurisdiction.
- C. Natural-gas piping will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.11 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain earthquake valves.

3.12 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG

- A. Aboveground, branch piping NPS 2 and smaller shall be one of the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints or wrought steel fittings with press joints.
- B. Aboveground, distribution piping shall be one of the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints for 2 inch and smaller.
 - 2. Steel pipe with wrought-steel fittings and welded joints or press joints for 2-1/2 inch and larger.

3.13 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG AND LESS THAN 5 PSIG

- A. Aboveground, distribution piping shall be the following:
 - 1. Steel pipe with steel welding fittings and welded joints.

3.14 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Distribution piping valves for pipe sizes NPS 2 and smaller shall be one of the following:
 - 1. Two-piece, full-port, bronze ball valves with bronze trim.
 - 2. Bronze plug valve.
- B. Distribution piping valves for pipe sizes NPS 2-1/2 and larger shall be one of the following:
 - 1. Two-piece, full-port, bronze ball valves with bronze trim.
 - 2. Bronze plug valve.
- C. Valves in branch piping for single appliance shall be one of the following:
 - 1. Two-piece, full-port, bronze ball valves with bronze trim.
 - 2. Bronze plug valve.

END OF SECTION

SECTION 22 11 23.21

INLINE, DOMESTIC-WATER PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

- 1. Vertically mounted, in-line, close-coupled centrifugal pumps.

B. Related Requirements:

- 1. Section 221123.13 "Domestic-Water Packaged Booster Pumps" for booster systems.
- 2. Section 331113 "Potable Water Supply Wells" for well pumps.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include construction materials, rated capacities, certified performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Detail pumps and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

- 1. Structural members to which pumps will be attached.
- 2. Size and location of initial access modules for acoustical tile.

- B. Seismic Qualification Data: Certificates, for inline, domestic-water pumps, accessories, and components, from manufacturer.

- 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
- 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
- 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For inline, domestic-water pumps to include in operation and maintenance manuals.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Retain shipping flange protective covers and protective coatings during storage.
- B. Protect bearings and couplings against damage.
- C. Comply with pump manufacturer's written instructions for handling.

PART 2 - PRODUCTS

2.1 DOMESTIC BOOSTER PUMP

- A. Furnish and install a prefabricated Triplex variable speed water pressure booster system model PR022TX106VFD as manufactured by SyncroFlo, Inc., Norcross, GA, and distributed by Gustavo Preston Company of Chelmsford, MA 978-250-3333. The system shall be capable of providing a constant system pressure of 80 Psig with flow rates from 0 to 240 GPM when suction pressure is 24 Psig minimum using 460 Volt, 3 PHASE, 60 hertz power.
- B. Each pump shall deliver 120 GPM at 139 FT TDH using a 10 HP, 3500 RPM motor.

2.2 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. UL Compliance: UL 778 for motor-operated water pumps.
- C. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.

2.3 VERTICALLY MOUNTED, IN-LINE, CLOSE-COUPLED CENTRIFUGAL PUMPS

- A. Description: Factory-assembled and -tested, in-line, single-stage, close-coupled, overhung-impeller centrifugal pumps designed for installation with pump and motor shaft mounted vertical.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Bell & Gossett; a Xylem brand.
 - 2. Grundfos Pumps Corp.
 - 3. TACO Comfort Solutions, Inc.
- C. Capacities and Characteristics:

1. Capacity: See drawing schedule.
2. Total Dynamic Head: See drawing schedule.
3. Casing Material: Bronze.
4. Impeller Material: Stainless steel.
5. Minimum Operating Pressure: 175 psig.
6. Maximum Continuous Operating Temperature: 225 deg F.
7. Inlet and Outlet Size: See drawing schedule.
8. Pump Control: Thermostat.
9. Pump Speed: See drawing schedule.
10. Motor Horsepower: See drawing schedule.
11. Electrical Characteristics:
 - a. Volts: 120 V.
 - b. Phases: Single phase.
 - c. Hertz: 60 Hz.
 - d. Full-Load Amperes: See drawing schedule.
 - e. Minimum Circuit Ampacity: See drawing schedule.
 - f. Maximum Overcurrent Protection: See drawing schedule.

D. Pump Construction:

1. Casing: Radially split bronze, with wear rings and threaded companion-flange connections for pumps with NPS 2 pipe connections and flanged connections for pumps with NPS 2-1/2 pipe connections
2. Impeller: Stainless steel, statically and dynamically balanced, closed, and keyed to shaft.
3. Shaft and Shaft Sleeve: Stainless steel shaft, with copper-alloy shaft sleeve.
4. Shaft Coupling: Flexible or rigid type if pump is provided with coupling.
5. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.
6. Bearings: Oil-lubricated; bronze-journal or ball type.
7. Minimum Working Pressure: 175 psig.
8. Continuous Operating Temperature: 225 deg F.

E. Motor: Single speed, with grease-lubricated ball bearings; rigidly mounted to pump casing.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.5 CONTROLS

A. Thermostats: Electric; adjustable for control of hot-water circulation pump.

1. Type: Water-immersion temperature sensor, for installation in piping.
2. Range: 65 to 200 deg F.
3. Enclosure: NEMA 250, Type 4X.
4. Operation of Pump: On or off.

5. Transformer: Provide if required.
6. Power Requirement: 120 V ac.
Settings: Start pump at 115 deg F and stop pump at 125 deg F.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for domestic-water-piping system to verify actual locations of piping connections before pump installation.

3.2 PUMP INSTALLATION

- A. Comply with HI 1.4.
- B. Mount pumps in orientation complying with manufacturer's written instructions.
- C. Install continuous-thread hanger rods and vibration isolation of size required to support pump weight.
 1. Comply with requirements for hangers and supports specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
- D. Install thermostats in hot-water return piping.

3.3 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to inline, domestic-water pumps, allow space for service and maintenance.
- C. Connect domestic-water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.
- D. Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping. Comply with requirements for strainers specified in Section 221119 "Domestic Water Piping Specialties." Comply with requirements for valves specified in the following:
 1. Section 220523.12 "Ball Valves for Plumbing Piping."
 2. Section 220523.13 "Butterfly Valves for Plumbing Piping."
 3. Section 220523.14 "Check Valves for Plumbing Piping."

3.4 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between temperature controllers and devices.

3.5 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment" for identification of pumps.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections[with the assistance of a factory-authorized service representative].
- E. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- F. Inline, domestic-water pump will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.

3.7 STARTUP SERVICE

- A. [Engage a factory-authorized service representative to perform] [Perform] startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping.
 - 4. Set thermostats for automatic starting and stopping operation of pumps.
 - 5. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in the correct direction.
 - 6. Prime pump by opening suction valves and closing drains and prepare pump for operation.

7. Start motor.
8. Open discharge valve slowly.
9. Adjust temperature settings on thermostats.
10. Adjust timer settings.

3.8 ADJUSTING

- A. Adjust inline, domestic-water pumps to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust initial temperature set points.
- C. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

END OF SECTION

DRA Project No. 20202.00

MSBA 90% CD Construction Documents - May 12, 2023

Bala Project No. 60-20-409

Northeast Metropolitan Regional Vocational High School

Wakefield, MA

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SECTION 221316

SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Pipe, tube, and fittings.
2. Specialty pipe fittings.
3. Roof flashing Assemblies.
4. Through-penetration firestop assemblies.
5. Miscellaneous sanitary drainage piping assemblies.
6. Flashing materials.

1.3 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
 1. Soil, Waste, and Vent Piping: 10-foot head of water.
 2. Waste, Force-Main Piping: 50 psig.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, and be marked with the collective trademark of the Cast Iron Soil Pipe Institute.
- B. Comply with NSF/ANSI 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 74, Service class(es).
- B. Gaskets: ASTM C 564, rubber.
- C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 888 or CISPI 301.
- B. Sovent Stack Fittings: ASME B16.45 or ASSE 1043, hubless, cast-iron aerator and deaerator drainage fittings.
- C. Heavy-Duty, Hubless-Piping Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Husky D 4000.
 - b. Clamp-All Corp. 125
 - c. MG.
 - 2. Standards: ASTM C 1540.
 - 3. Description: 304 Stainless-steel shield with 304 stainless-steel bands and 304 stainless-steel tightening devices; and ASTM C 564, neoprene sleeve with integral, center pipe stop.

2.4 GALVANIZED-STEEL PIPE AND FITTINGS

- A. Galvanized-Steel Pipe: ASTM A 53/A 53M, Type E, Standard Weight class. Include square-cut-grooved or threaded ends matching joining method.
- B. Galvanized-Cast-Iron Drainage Fittings: ASME B16.12, threaded.
- C. Steel Pipe Pressure Fittings:
 - 1. Galvanized-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106/A 106M, Schedule 40, seamless steel pipe. Include ends matching joining method.
 - 2. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
 - 3. Galvanized-Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, standard pattern.

D. Grooved-Joint, Galvanized-Steel-Pipe Appurtenances:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International.
 - b. Grinnell Mechanical Products.
 - c. Shurjoint Piping Products.
 - d. Smith-Cooper International.
 - e. Victaulic Company.
2. Galvanized, Grooved-End Fittings for Galvanized-Steel Piping: ASTM A 536 ductile-iron castings, ASTM A 47/A 47M malleable-iron castings, ASTM A 234/A 234M forged steel fittings, or ASTM A 106/A 106M steel pipes with dimensions matching ASTM A 53/A 53M steel pipe, and complying with AWWA C606 for grooved ends.
3. Grooved Mechanical Couplings for Galvanized-Steel Piping: ASTM F 1476, Type I. Include ferrous housing sections with continuous curved keys; EPDM-rubber gasket suitable for hot and cold water; and bolts and nuts.

2.5 COPPER TUBE AND FITTINGS

- A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
- B. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.
- C. Hard Copper Tube: ASTM B 88, Type L and Type M, water tube, drawn temper.
- D. Soft Copper Tube: ASTM B 88, Type L, water tube, annealed temper.
- E. Copper Pressure Fittings:
 1. Copper Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 2. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
- F. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
 1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- G. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.
- H. Transition Couplings:
 1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
 2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
 3. Unshielded, Nonpressure Transition Couplings:

- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Dallas Specialty & Mfg. Co.
 - 2) Fernco Inc.
 - 3) Froet Industries LLC.
 - 4) Mission Rubber Company, LLC; a division of MCP Industries.
 - 5) Plastic Oddities.
 - b. Standard: ASTM C 1173.
 - c. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - d. Sleeve Materials:
 - 1) For Cast-Iron Soil Pipes: ASTM C 564, rubber.
 - 2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 - 3) For Dissimilar Pipes: ASTM D 5926, PVC, or other material compatible with pipe materials being joined.
4. Shielded, Nonpressure Transition Couplings:
- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Cascade Waterworks Mfg. Co.
 - 2) Mission Rubber Company, LLC; a division of MCP Industries.
 - b. Standard: ASTM C 1460.
 - c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
5. Pressure Transition Couplings:
- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Cascade Waterworks Mfg. Co.
 - 2) Dresser, Inc.
 - 3) EBAA Iron, Inc.
 - 4) Ford Meter Box Company, Inc. (The).
 - 5) Jay R. Smith Mfg. Co.
 - 6) JCM Industries, Inc.
 - 7) Romac Industries, Inc.
 - 8) Viking Johnson.
 - b. Standard: AWWA C219.
 - c. Description: Metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
 - d. Center-Sleeve Material: Manufacturer's standard.
 - e. Gasket Material: Natural or synthetic rubber.

- f. Metal Component Finish: Corrosion-resistant coating or material.

I. Dielectric Fittings:

1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
2. Dielectric Unions:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) A.Y. McDonald Mfg. Co.
 - 2) Capitol Manufacturing Company.
 - 3) Central Plastics Company.
 - 4) HART Industrial Unions, LLC.
 - 5) Jomar Valve.
 - 6) Matco-Norca.
 - 7) Watts; a Watts Water Technologies company.
 - 8) Wilkins.
 - 9) Zurn Industries, LLC.
 - b. Description:
 - 1) Standard: ASSE 1079.
 - 2) Pressure Rating: 125 psig minimum at 180 deg F.
 - 3) End Connections: Solder-joint copper alloy and threaded ferrous.
3. Dielectric Flanges:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Capitol Manufacturing Company.
 - 2) Central Plastics Company.
 - 3) Matco-Norca.
 - 4) Watts; a Watts Water Technologies company.
 - 5) Wilkins.
 - 6) Zurn Industries, LLC.
 - b. Description:
 - 1) Standard: ASSE 1079.
 - 2) Factory-fabricated, bolted, companion-flange assembly.
 - 3) Pressure Rating: 125 psig minimum at 180 deg F.
 - 4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
4. Dielectric Nipples:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Elster Perfection Corporation.

- 2) Grinnell Mechanical Products.
- 3) Matco-Norca.
- 4) Precision Plumbing Products.
- 5) Victaulic Company.

b. Description:

- 1) Standard: IAPMO PS 66
- 2) Electroplated steel nipple.
- 3) Pressure Rating: 300 psig at 225 deg F.
- 4) End Connections: Male threaded or grooved.
- 5) Lining: Inert and noncorrosive, propylene.

2.6 PVC PIPING

- A. Shall be used for underslab drainage system. Refer to Piping Schedule 3.11.

2.7 CLEANOUTS

A. Exposed Metal Cleanouts:

1. ASME A112.36.2M, Cast-Iron Cleanouts:

- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- 1) Jay R. Smith Mfg. Co.
- 2) Josam Company.
- 3) Charlotte Pipe and Foundry
- 4) Tyler Pipe; a subsidiary of McWane Inc.
- 5) Watts; a Watts Water Technologies company.
- 6) Zurn Industries, LLC.

2. ASME A112.3.1, Stainless-Steel Cleanouts:

- a. Manufacturers: Subject to compliance with requirements, provide products by the following:

- 1) Josam Company.
- 2) Sun Drainage Products

3. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
4. Size: Same as connected drainage piping.
5. Body Material: as required to match connected piping.
6. Closure: Countersunk or raised-head plug.
7. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
8. Closure: Stainless-steel plug with seal.

B. Metal Floor Cleanouts:

1. ASME A112.36.2M, Cast-Iron Cleanouts:

- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- 1) Jay R. Smith Mfg. Co.
- 2) Josam Company.
- 3) Charlotte Pipe and Foundry
- 4) Sioux Chief Manufacturing Company, Inc.
- 5) Tyler Pipe; a subsidiary of McWane Inc.
- 6) Watts; a Watts Water Technologies company.
- 7) Zurn Industries, LLC.

2. ASME A112.36.2M, Stainless-Steel Cleanouts:

- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- 1) Jay R. Smith Mfg. Co.
- 2) Josam Company.
- 3) Sun Drainage Products
- 4) Zurn Industries, LLC.

3. ASME A112.3.1, Stainless-Steel Cleanouts:

- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- 1) Josam Company.
- 2) Sun Drainage Products
- 3) Zurn Industries, LLC.

4. Standard: ASME A112.36.2M for cast-iron soil pipe with cast-iron ferrule or heavy-duty, adjustable housing cleanout.
5. Size: Same as connected branch.
6. Type: Cast-iron soil pipe with cast-iron ferrule or Heavy-duty, adjustable housing.
7. Body or Ferrule: Cast iron.
8. Clamping Device: Required.
9. Outlet Connection: As required.
10. Closure: Brass plug with tapered threads.
11. Adjustable Housing Material: Cast iron.
12. Frame and Cover Material and Finish: Rough bronze.
13. Frame and Cover Shape: Round.
14. Top Loading Classification: Heavy Duty.
15. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
16. Standard: ASME A112.3.1.
17. Size: Same as connected branch.
18. Housing: Stainless steel.
19. Closure: Stainless steel with seal.
20. Riser: Stainless-steel drainage pipe fitting to cleanout.

C. Cast-Iron Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Jay R. Smith Mfg. Co.
- b. Josam Company.
- c. Charlotte Pipe and Foundry

- d. Tyler Pipe; a subsidiary of McWane Inc.
 - e. Watts; a Watts Water Technologies company.
 - f. Zurn Industries, LLC.
2. Standard: ASME A112.36.2M. Include wall access.
 3. Size: Same as connected drainage piping.
 4. Body: as required to match connected piping.
 5. Closure: Countersunk or raised-head brass plug.
 6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
 7. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.
 8. Wall Access: Round stainless-steel wall-installation frame and cover.

2.8 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. ProSet Systems Inc.
2. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.
3. Size: Same as connected soil, waste, or vent stack.
4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
5. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
6. Special Coating: Corrosion resistant on interior of fittings.

2.9 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:

1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564, rubber gaskets.
2. Size: Same as connected waste piping.

B. Floor-Drain, Trap-Seal Primer Fittings:

1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

C. Air-Gap Fittings:

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.

5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

D. Sleeve Flashing Device:

1. Description: Manufactured, cast-iron fitting, with clamping device, that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 2 inches above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping.

E. Stack Flashing Fittings:

1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
2. Size: Same as connected stack vent or vent stack.

F. Vent Caps:

1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
2. Size: Same as connected stack vent or vent stack.

2.10 FLASHING MATERIALS

A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:

1. General Use: 4.0-lb/sq. ft., 0.0625-inch thickness.
2. Vent Pipe Flashing: 3.0-lb/sq. ft., 0.0469-inch thickness.
3. Burning: 6-lb/sq. ft., 0.0938-inch thickness.

B. Copper Sheet: ASTM B 152/B 152M, of the following minimum weights and thicknesses, unless otherwise indicated:

1. General Applications: 12 oz./sq. ft.
2. Vent Pipe Flashing: 8 oz./sq. ft.

C. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness, unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.

D. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.

E. Fasteners: Metal compatible with material and substrate being fastened.

F. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

G. Solder: ASTM B 32, lead-free alloy.

- H. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

PART 3 - EXECUTION

3.1 EARTH MOVING

- A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping at indicated slopes.
- F. Install piping free of sags and bends.
- G. Install fittings for changes in direction and branch connections.
- H. Install piping to allow application of insulation.
- I. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- J. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

- K. Install soil and waste drainage and vent piping at the following minimum slopes unless otherwise indicated:
 - 1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 2 percent downward in direction of flow for piping NPS 4 and larger.
 - 2. Horizontal Sanitary Drainage Piping: 1 percent downward in direction of flow.
 - 3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
- L. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
 - 1. Install encasement on underground piping according to ASTM A 674 or AWWA C105/A 21.5.
- M. Install steel piping according to applicable plumbing code.
- N. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."
- O. Install aboveground PVC piping according to ASTM D 2665.
- P. Install underground PVC piping according to ASTM D 2321.
- Q. Install underground, force-main piping according to AWWA C600. Install buried piping inside building between wall and floor penetrations and connection to sanitary sewer piping outside building with restrained joints. Anchor pipe to wall or floor. Install thrust-block supports at vertical and horizontal offsets.
- R. Install underground, copper, force-main tubing according to CDA's "Copper Tube Handbook."
- S. Install force mains at elevations indicated.
- T. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- U. Install sleeves for piping penetrations of walls, ceilings, and floors.
- V. Install sleeve seals for piping penetrations of concrete walls and slabs.
- W. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.3 JOINT CONSTRUCTION

- A. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- B. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum calked joints.
- C. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.
- D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- E. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.
- F. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.
- G. Plastic, Nonpressure-Piping, Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 2. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in OD's.
2. In Drainage Piping: Unshielded, nonpressure transition couplings.
3. In Aboveground Force Main Piping: Fitting-type transition couplings.
4. In Underground Force Main Piping:
 - a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
 - b. NPS 2 and Larger: Pressure transition couplings.

B. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples or unions.
3. Dielectric Fittings for NPS 2-1/2 and larger: Use dielectric nipples.

3.5 VALVE INSTALLATION

A. Shutoff Valves:

1. Install shutoff valve on each sewage pump discharge.
2. Install gate or full-port ball valve for piping NPS 2 and smaller.
3. Install gate valve for piping NPS 2-1/2 and larger.

B. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
 2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
 3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
 4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
 5. Vertical Piping: MSS Type 8 or Type 42, clamps.
 6. Install individual, straight, horizontal piping runs:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
 7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 8. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Support horizontal piping and tubing within 12 inches of each fitting, valve and coupling.
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.
- E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
 2. NPS 3: 60 inches with 1/2-inch rod.
 3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
 4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
 5. NPS 10 and NPS 12: 60 inches with 7/8-inch rod.
 6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- F. Install supports for vertical cast-iron soil piping every 15 feet.
- G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/4: 84 inches with 3/8-inch rod.
 2. NPS 1-1/2: 108 inches with 3/8-inch rod.
 3. NPS 2: 10 feet with 3/8-inch rod.
 4. NPS 2-1/2: 11 feet with 1/2-inch rod.
 5. NPS 3: 12 feet with 1/2-inch rod.
 6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
 7. NPS 6 and NPS 8: 12 feet with 3/4-inch rod.
 8. NPS 10 and NPS 12: 12 feet with 7/8-inch rod.
- H. Install supports for vertical steel piping every 15 feet.

- I. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/4: 72 inches with 3/8-inch rod.
 - 2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
 - 3. NPS 2-1/2: 108 inches with 1/2-inch rod.
 - 4. NPS 3 and NPS 5: 10 feet with 1/2-inch rod.
 - 5. NPS 6: 10 feet with 5/8-inch rod.
 - 6. NPS 8: 10 feet with 3/4-inch rod.
- J. Install supports for vertical copper tubing every 10 feet.
- K. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect drainage and vent piping to the following:
 - 1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
 - 2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
 - 3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
 - 4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
 - 5. Equipment: Connect drainage piping as indicated. Provide shutoff valve if indicated and union for each connection.
- D. Connect force-main piping to the following:
 - 1. Sanitary Sewer: To exterior force main.
 - 2. Sewage Pump: To sewage pump discharge.
- E. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
- F. Make connections according to the following unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

- A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections, and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping except outside leaders on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
 - 4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
 - 5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 6. Prepare reports for tests and required corrective action.
- E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 - 3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 4. Prepare reports for tests and required corrective action.

3.10 CLEANING AND PROTECTION

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.11 PIPING SCHEDULE

- A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. Aboveground, sanitary waste and vent piping shall be any of the following:
 - 1. Hubless, cast-iron soil pipe and fittings heavy-duty hubless-piping couplings; and coupled joints.
 - 2. Galvanized-steel pipe, drainage fittings, and threaded joints.
 - 3. Copper DWV tube, copper drainage fittings, and soldered joints.
- C. Underground, soil, waste, and vent piping shall be any of the following:
 - 1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 - 2. Hub and spigot cast iron piping with lead and oakum joints.
 - 3. Dissimilar Pipe-Material Couplings: Unshielded, nonpressure transition couplings.
- D. Aboveground sanitary-sewage force mains shall be any of the following:
 - 1. Hard copper tube, Type L; copper pressure fittings; and soldered joints.
 - 2. Galvanized-steel pipe, pressure fittings, and threaded joints.
 - 3. Grooved-end, galvanized-steel pipe; grooved-joint, galvanized-steel-pipe appurtenances; and grooved joints.
- E. PVC pipe for under-slab drainage system:
 - 1. PVC pipe shall conform to the requirements of Mass DOT M4.03.7 (2023 Edition).
 - 2. For perforated pipes, the perforations shall be along two lines parallel to the axis of the pipe located at 120 degrees from each other. The perforations shall be ½ inch in diameter and shall be placed facing down.

3.12 INSTALLATION

- A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
 - 1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 - 2. Locate at each change in direction of piping greater than 45 degrees.
 - 3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
 - 4. Locate at base of each vertical soil and waste stack.

- B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- D. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
 - 1. Position floor drains for easy access and maintenance.
 - 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
 - 3. Install floor-drain flashing collar or flange and flash accordingly so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
 - 4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- E. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
 - 1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
 - 2. Size: Same as floor drain inlet.
- F. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system. Center indirect waste piping directly over drain receiving waste and include required air gap and 90° turn down elbow at discharge location.
- G. Install sleeve flashing device with each riser and stack passing through floors.
- H. Install frost-resistant vent terminals on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.
- I. Install wood-blocking reinforcement for wall-mounting-type specialties.
- J. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.13 FLASHING INSTALLATION

- A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
 - 1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
 - 2. Copper Sheets: Solder joints of copper sheets.
- B. Install sheet flashing on pipes, sleeves, floor drains, and specialties passing through or embedded in floors and roofs.
 - 1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.

2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
 3. Embedded Floor Drain and Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around drain or specialty.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.
- E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings.
- F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.
- G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

END OF SECTION

SECTION 22 14 13

STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Pipe, tube, and fittings.
 - 2. Specialty pipe fittings.
 - 3. Encasement for underground metal piping.
 - 4. Cleanouts
 - 5. Through-penetration firestop assemblies
 - 6. Flashing materials.

1.3 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
 - 1. Storm Drainage Piping: 10-foot head of water.
 - 2. Storm Drainage, Force-Main Piping: 50 psig.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.2 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 888 or CISPI 301.
- B. Heavy-Duty, Hubless-Piping Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. ANACO-Husky.
 - b. Clamp-All Corp.
 - c. Dallas Specialty & Mfg. Co.
 - d. MIFAB, Inc.
 - e. Mission Rubber Company, LLC; a division of MCP Industries.
 - f. Stant.
 - g. Tyler Pipe; a subsidiary of McWane Inc.
2. Standards: ASTM C 1277 and ASTM C 1540.
 3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.3 GALVANIZED-STEEL PIPE AND FITTINGS

- A. Galvanized-Steel Pipe: ASTM A 53/A 53M, Type E, Standard Weight. Include square-cut-grooved or threaded ends matching joining method.
- B. Galvanized-Cast-Iron Drainage Fittings: ASME B16.12 threaded.
- C. Steel-Pipe Pressure Fittings:
 1. Galvanized-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106/A 106M, Schedule 40, seamless steel pipe. Include ends matching joining method.
 2. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
 3. Galvanized-Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, standard pattern.
- D. Grooved-Joint, Galvanized-Steel-Pipe Appurtenances:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International.
 - b. Grinnell Mechanical Products.
 - c. Shurjoint Piping Products.
 - d. Smith-Cooper International.
 - e. Victaulic Company.
 2. Galvanized, Grooved-End Fittings for Galvanized-Steel Piping: ASTM A 536 ductile-iron castings, ASTM A 47/A 47M malleable-iron castings, ASTM A 234/A 234M forged-steel fittings, or ASTM A 106/A 106M steel pipes with dimensions matching ASTM A 53/A 53M steel pipe, and complying with AWWA C606 for grooved ends.
 3. Grooved Mechanical Couplings for Galvanized-Steel Piping: ASTM F 1476, Type I. Include ferrous housing sections with continuous curved keys; EPDM-rubber gasket suitable for hot and cold water; and bolts and nuts.

2.4 COPPER TUBE AND FITTINGS

- A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
- B. Copper Drainage Fittings: ASME B16.23, cast-copper fittings or ASME B16.29, wrought-copper, solder-joint fittings.

- C. Hard Copper Tube: ASTM B 88, Type L, water tube, drawn temper.
- D. Soft Copper Tube: ASTM B 88, Type L, water tube, annealed temper.
- E. Copper Pressure Fittings:
 - 1. Copper Fittings: ASME B16.18, cast-copper-alloy fittings or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
- F. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
 - 1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 - 2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- G. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.5 CLEANOUTS

- A. Floor Cleanouts:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. Sun Drainage Products
 - d. Sioux Chief Manufacturing Company, Inc.
 - e. Tyler Pipe; a subsidiary of McWane Inc.
 - f. Watts; a Watts Water Technologies company.
 - g. Zurn Industries, LLC.
 - 2. Standard: ASME A112.36.2M, for cast-iron soil pipe with cast-iron ferrule or heavy-duty, adjustable housing cleanouts.
 - 3. Size: Same as connected branch.
 - 4. Type: Cast-iron soil pipe with cast-iron ferrule or Heavy-duty, adjustable housing.
 - 5. Body or Ferrule Material: Cast iron.
 - 6. Clamping Device: Required.
 - 7. Outlet Connection: As required.
 - 8. Closure: Brass plug with straight threads and gasket.
 - 9. Adjustable Housing Material: Cast iron.
 - 10. Frame and Cover Material and Finish: Rough bronze.
 - 11. Frame and Cover Shape: Round.
 - 12. Top-Loading Classification: Heavy Duty.
 - 13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
- B. Test Tees:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.

- b. Josam Company.
 - c. Sun Drainage Products
 - d. Tyler Pipe; a subsidiary of McWane Inc.
 - e. Watts; a Watts Water Technologies company.
 - f. Zurn Industries, LLC.
2. Standard: ASME A112.36.2M and ASTM A 74, ASTM A 888, or CISPI 301, for cleanout test tees.
3. Size: Same as connected drainage piping.
4. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or hubless, cast-iron soil-pipe test tee as required to match connected piping.
5. Closure Plug: Countersunk or raised head, brass.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

C. Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. Sun Drainage Products
 - d. Tyler Pipe; a subsidiary of McWane Inc.
 - e. Watts; a Watts Water Technologies company.
 - f. Zurn Industries, LLC.
2. Standard: ASME A112.36.2M, for cleanouts. Include wall access.
3. Size: Same as connected drainage piping.
4. Body Material: As required to match connected piping.
5. Closure: Countersunk or raised-head plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.
8. Wall Access: Round stainless-steel wall-installation frame and cover.

2.6 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. ProSet Systems Inc.
2. Standard: ASTM E 814, for through-penetration firestop assemblies.
3. Certification and Listing: Testing agency acceptable to authorities having jurisdiction for through-penetration firestop assemblies.
4. Size: Same as connected pipe.
5. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
6. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
7. Special Coating: Corrosion resistant on interior of fittings.

2.7 FLASHING MATERIALS

- A. Copper Sheet: ASTM B 152/B 152M, 12 oz./sq. ft.
- B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.
- C. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.
- D. Fasteners: Metal compatible with material and substrate being fastened.
- E. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
- F. Solder: ASTM B 32, lead-free alloy.

PART 3 - EXECUTION

3.1 EARTH MOVING

- A. Comply with requirements for excavating, trenching, and backfilling specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations from layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of

standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

- K. Lay buried building storm drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
- L. Install storm drainage piping at the following minimum slopes unless otherwise indicated:
 - 1. Building Storm Drain: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
 - 2. Horizontal Storm-Drainage Piping: 1 percent downward in direction of flow.
- M. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
- N. Install aboveground PVC piping according to ASTM D 2665.
- O. Install underground PVC piping according to ASTM D 2321.
- P. Install copper, force-main tubing according to CDA's "Copper Tube Handbook."
- Q. Install force mains at elevations indicated.
- R. Plumbing Specialties:
 - 1. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping.
- S. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- T. Install sleeves for piping penetrations of walls, ceilings, and floors.
- U. Install sleeve seals for piping penetrations of concrete walls and slabs.
- V. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.3 JOINT CONSTRUCTION

- A. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- B. Hub-and-Spigot, Cast-Iron Soil Piping Calked Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead-and-oakum calked joints.
- C. Hubless, Cast-Iron Soil Piping Coupled Joints: Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.
- D. Join copper tube and fittings with soldered joints according to ASTM B 828 procedure. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.

- E. Plastic, Non-Pressure-Piping, Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.4 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
 - 2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
 - 3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
 - 4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
 - 5. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 6. Individual, Straight, Horizontal Piping Runs:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
 - 7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - 8. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Support horizontal piping and tubing within 12 inches of each fitting and coupling.
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.
- E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
 - 2. NPS 3: 60 inches with 1/2-inch rod.
 - 3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
 - 4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
 - 5. NPS 10 and NPS 12: 60 inches with 7/8-inch rod.
 - 6. Spacing for 10-foot pipe lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- F. Install supports for vertical cast-iron soil piping every 15 feet.
- G. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/4: 72 inches with 3/8-inch rod.
 - 2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
 - 3. NPS 2-1/2: 108 inches with 1/2-inch rod.

4. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
5. NPS 6: 10 feet with 5/8-inch rod.
6. NPS 8: 10 feet with 3/4-inch rod.

H. Install supports for vertical copper tubing every 10 feet.

I. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
2. NPS 3: 48 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
4. NPS 6 and NPS 8: 48 inches with 3/4-inch rod.
5. NPS 10 and NPS 12: 48 inches with 7/8-inch rod.

J. Install supports for vertical PVC piping every 48 inches.

K. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.5 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect storm drainage piping to roof drains and storm drainage specialties.

1. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.

D. Connect force-main piping to the following:

1. Sump Pumps: To sump pump discharge.

E. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

3.6 IDENTIFICATION

A. Identify exposed storm drainage piping. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.7 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 3. Test Procedure: Test storm drainage piping on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts until completion of inspection, water level must not drop. Inspect joints for leaks.
 - 4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 5. Prepare reports for tests and required corrective action.
- E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 - 3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 4. Prepare reports for tests and required corrective action.

3.8 CLEANING

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.9 PIPING SCHEDULE

- A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. Aboveground storm drainage piping shall be any of the following:
 - 1. Hubless, cast-iron soil pipe and fittings; heavy-duty, hubless-piping couplings; and coupled joints.
 - 2. Copper DWV tube, copper drainage fittings, and soldered joints.

C. Underground storm drainage piping shall be the following:

1. Service Weight Hub Type cast-iron soil pipe and fittings; with gasketed joints and fittings.

3.10 INSTALLATION

A. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.

1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
2. Install expansion joints, if indicated, in roof drain outlets.
3. Position roof drains for easy access and maintenance.

B. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:

1. Use cleanouts the same size as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
3. Locate cleanouts at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate cleanouts at base of each vertical soil and waste stack.

C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

E. Install test tees in vertical conductors and near floor.

F. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

G. Install through-penetration firestop assemblies in plastic conductors at concrete floor penetrations.

H. Install sleeve flashing device with each conductor passing through floors with waterproof membrane.

3.11 FLASHING INSTALLATION

A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of 6.0-lb/sq. ft. lead sheets, 0.0938-inch thickness or thicker. Solder joints of 4.0-lb/sq. ft. lead sheets, 0.0625-inch thickness or thinner.
2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, drains, and specialties passing through or embedded in floors and roofs.

1. Pipe Flashing: Sleeve type, matching the pipe size, with a minimum length of 10 inches and with skirt or flange extending at least 8 inches around pipe.

2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.
- E. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.12 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION

SECTION 22 41 00

PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for lavatories.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Counter cutout templates for mounting of counter-mounted plumbing fixtures.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For plumbing fixtures and faucets to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 REFERENCE PLUMBING FIXTURE SPECIFICATION SCHEDULES ON DRAWINGS.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of water-supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing-fixture installation.
- B. Examine walls, floors, cabinets, and counters for suitable conditions where fixtures will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install plumbing fixtures level and plumb according to roughing-in drawings.
- B. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.
- C. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.
- D. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
- E. Install flush valves actuators in locations that are easy for people with disabilities to reach.
- F. Install fresh batteries in battery-powered, electronic-sensor faucet and flush valve mechanisms.
- G. Install counter-mounting fixtures in and attached to casework.
- H. Install pedestal lavatories on pedestals and secured to wood blocking in wall.
- I. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
 - 1. Exception: Use ball or gate valves if supply stops are not specified with fixture.
- J. Install toilet seats on water closets.
- K. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
- L. Install shower flow-control fittings with specified maximum flow rates in shower arms.
- M. Install traps on fixture outlets.
 - 1. Exception: Omit trap on fixtures with integral traps.
 - 2. Exception: Omit trap on indirect wastes unless otherwise indicated.
- N. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible fixtures.
- O. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings.
- P. Seal joints between plumbing fixtures, counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color.

3.3 CONNECTIONS

- A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

3.4 ADJUSTING

- A. Operate and adjust plumbing fixtures and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
- B. Adjust water pressure at faucets and flush valves to produce proper flow.
- C. Adjust all infrared sensors for proper operation and duration as required.

3.5 CLEANING AND PROTECTION

- A. After completing installation of plumbing fixtures, inspect and repair damaged finishes.
- B. Clean plumbing fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed plumbing fixtures and fittings.
- D. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION

SECTION 22 45 00

EMERGENCY PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Emergency showers.
 - 2. Eyewash equipment.
 - 3. Eye/face wash equipment.
 - 4. Combination units.
 - 5. Supplemental equipment.
 - 6. Water-tempering equipment.

1.3 DEFINITIONS

- A. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.
- B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.
- C. Self-Contained Emergency Plumbing Fixture: Fixture with flushing-fluid-solution supply.
- D. Tepid: Moderately warm.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and mounting attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 - 4. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Product Certificates: Submit certificates of performance testing specified in "Source Quality Control" Article.
- B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For emergency plumbing fixtures to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Flushing-Fluid Solution: Separate lot and equal to at least 200 percent of amount of solution installed for each self-contained unit.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ISEA Standard: Comply with ISEA Z358.1.
- C. NSF Standard: Comply with NSF 61 and NSF 372, for fixture materials that will be in contact with potable water.
- D. Regulatory Requirements: Comply with requirements in ICC A117.1, ; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

2.2 EMERGENCY SHOWERS

- A. Freestanding, Plumbed Emergency Showers,
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bradley Corporation.
 - b. Encon Safety Products.
 - c. Guardian Equipment Co.
 - d. Haws Corporation.
 - 2. Capacity: Not less than 20 gpm for at least 15 minutes.
 - 3. Supply Piping: NPS 1 with flow regulator and stay-open control valve.
 - 4. Control-Valve Actuator: Pull rod
 - 5. Shower Head: 8-inch-minimum-diameter, stainless steel

6. Mounting: Recessed, Pedestal.

2.3 COMBINATION UNITS

A. Standard, Plumbed Emergency Shower with Eyewash Combination Units,

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bradley Corporation.
 - b. Encon Safety Products.
 - c. Guardian Equipment Co.
 - d. Haws Corporation.
2. Piping:
 - a. Material: Stainless Steel.
 - b. Unit Supply: NPS 1-1/2.
 - c. Unit Drain: Outlet at back or side near bottom.
3. Shower:
 - a. Capacity: Not less than 20 gpm for at least 15 minutes.
 - b. Supply Piping: NPS 1 with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Pull rod.
 - d. Shower Head: 8-inch-minimum diameter stainless steel
 - e. Mounting: Recessed, Pedestal.
4. Eyewash Unit:
 - a. Capacity: Not less than 0.4 gpm for at least 15 minutes.
 - b. Supply Piping: NPS 1/2 with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Paddle.
 - d. Spray-Head Assembly: Two receptor-mounted spray heads.
 - e. Receptor: Stainless steel drain pan, plastic bowl
 - f. Mounting: Attached shower pedestal.
 - g. Drench-Hose Option: May be provided instead of eyewash unit.
 - 1) Capacity: Not less than 0.4 gpm for at least 15 minutes.
 - 2) Drench Hose: Hand-held spray head with squeeze-handle actuator and hose.
 - 3) Mounting: Recessed, pedestal.

2.4 WATER-TEMPERING EQUIPMENT

A. Hot- and Cold-Water, Water-Tempering Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bradley Corporation.
 - b. Guardian Equipment Co.
 - c. Haws Corporation.
 - d. Lawler Manufacturing Company, Inc.
 - e. Leonard Valve Company.

- f. Speakman Company.
- g. Stingray Systems LLC.
- h. WATTS.

- 2. Description: Factory-fabricated equipment with thermostatic mixing valve.
 - a. Thermostatic Mixing Valve: Designed to provide 80 deg F tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F. 80 deg F throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.
 - b. Supply Connections: For hot and cold water.

2.5 SOURCE QUALITY CONTROL

- A. Certify performance of emergency plumbing fixtures by independent testing organization acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for water[**and waste**] piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF EMERGENCY PLUMBING FIXTURE INSTALLATION

- A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.
- B. Install fixtures level and plumb.
- C. Fasten fixtures to substrate.
- D. Install shutoff valves in water-supply piping to fixtures, to facilitate maintenance of the equipment. Use ball or gate valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Comply with requirements for valves specified in Section 220523.
 - 1. Exception: Omit shutoff valve on supply to group of plumbing fixtures that includes emergency equipment.
 - 2. Exception: Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.
- E. Install shutoff valve and strainer in steam piping and shutoff valve in condensate return piping. Comply with requirements for steam and condensate piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."

- F. Install dielectric fitting in supply piping to emergency equipment if piping and equipment connections are made of different metals. Comply with requirements for dielectric fittings specified in Section 221116 "Domestic Water Piping."
- G. Install thermometers in supply and outlet piping connections to water-tempering equipment. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."
- H. Install trap and waste piping on drain outlet of emergency equipment receptors that are indicated to be directly connected to drainage system. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."
- I. Install indirect waste piping on drain outlet of emergency equipment receptors that are indicated to be indirectly connected to drainage system. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."
- J. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."
- K. Fill self-contained fixtures with flushing fluid.

3.3 CONNECTIONS

- A. Connect cold-water-supply piping to plumbed emergency plumbing fixtures not having water-tempering equipment. Comply with requirements for cold-water piping specified in Section 221116 "Domestic Water Piping."
- B. Connect hot- and cold-water-supply piping to hot- and cold-water, water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for hot- and cold-water piping specified in Section 221116 "Domestic Water Piping."
- C. Connect steam and cold-water-supply and condensate return piping to steam and cold water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for cold-water piping specified in Section 221116 "Domestic Water Piping" and comply with requirements for steam and condensate piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."
- D. Connect cold water and electrical power to electric heating water-tempering equipment. Comply with requirements for cold-water piping specified in Section 221116 "Domestic Water Piping."
- E. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary waste and vent piping. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."
- F. Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to sanitary waste or storm drainage piping.
- G. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.4 IDENTIFICATION

- A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

- A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.
- B. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Emergency plumbing fixtures and water-tempering equipment will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust or replace fixture flow regulators for proper flow.
- B. Adjust equipment temperature settings.

END OF SECTION

SECTION 22 61 13

COMPRESSED-AIR PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Compressed-air piping
2. Shape-memory-metal couplings.
3. Pressure-seal fittings.
4. Flexible pipe connectors.
5. Zone valve box assemblies.
6. Ball valves.
7. Check valves.
8. Gas safety valves.
9. Compressed-air service connections.
10. Compressed-air manifolds.
11. Compressed-air cylinder storage racks.

- B. Related Requirements:

1. Section 221513 "General-Service Compressed-Air Piping" for general-service compressed-air piping and specialties.
2. Section 226119 "Compressed-Air Equipment" for air compressors and specialties.

1.3 DEFINITIONS

- A. Compressed-Air Piping Systems: Include compressed air.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer and testing agency.
- B. Material Certificates: Signed by Installer, certifying that medical compressed-air piping materials comply with requirements in NFPA 99 for positive-pressure medical gas systems.
- C. Brazing certificates.

- D. Field Quality-Control Reports: Brazing certificates.
- E. Source Quality Control Reports:
 - 1. Certificates of Shop Inspection and Data Report for Bulk Gas Storage Tanks: As required by ASME Boiler and Pressure Vessel Code, Section VIII.
- 1.6 CLOSEOUT SUBMITTALS
 - A. Operation and Maintenance Data: For compressed-air piping specialties to include in emergency, operation, and maintenance manuals.
- 1.7 MAINTENANCE MATERIAL SUBMITTALS
 - A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- 1.8 QUALITY ASSURANCE
 - A. Installer Qualifications:
 - 1. Shape-Memory-Metal Coupling Joints: An authorized representative who is trained and approved by manufacturer in accordance with ASSE Standard #6040.
 - B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum piping testing indicated, that is an NRTL, and that is acceptable to authorities having jurisdiction.
 - C. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications," or AWS B2.2/B2.2M.

PART 2 - PRODUCTS

- 2.1 SYSTEM DESCRIPTION
 - A. Compressed air operating at 150 psig.
- 2.2 PERFORMANCE REQUIREMENTS
 - A. Comply with NFPA 99.
- 2.3 PIPES, TUBES, AND FITTINGS
 - A. Comply with NFPA 99 for medical air piping materials.
 - 1. All positive-pressure compressed-air piping, tubing, and fittings shall be manufacturer cleaned, purged, and sealed as for oxygen service, in accordance with CGA G-4.1.
 - a. Each length of tubing shall be delivered plugged or capped by the manufacturer and kept sealed until prepared for installation.

- b. Fittings and other components shall be delivered manufacturer sealed and labeled and kept sealed until prepared for installation.
- B. Comply with ASME B31.1 for compressed air piping operating at more than 150 psig.
- C. Comply with ASME B31.9 for compressed air piping operating at 150 psig or less.
- D. Wrought-Copper Fittings: ASME B16.22, brazed-joint pressure type.
- E. Copper Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.
- F. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150.
 - 1. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness, full-face type.
 - 2. Flange Bolts and Nuts: ASME B18.2.1 carbon steel.
- G. Shape-Memory-Metal Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aerofit, Inc.
 - b. CAMERON; A Schlumber Co.
 - c. Motion Industries.
 - d. Smart Tap; Smart Technology, Inc.
 - 2. Description: Cryogenic compression fitting made of nickel-titanium, shape-memory alloy.
- H. Pressure-Seal Fittings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Viega LLC.
 - 2. NPS 2 and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.
 - 3. NPS 2-1/2 to NPS 4: Bronze fitting with stainless steel grip ring and EPDM O-ring seal in each end.
- I. Flexible Pipe Connectors:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flex-Hose Co., Inc.
 - b. Flexicraft Industries.
 - c. Hyspan Precision Products, Inc.
 - d. Mercer Rubber Co.
 - e. Metraflex Company (The).
 - f. Proco Products, Inc.
 - g. Universal Metal Hose.

2. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
 - a. Working-Pressure Rating: 200 psig minimum.
 - b. End Connections: Plain-end copper tube.

2.4 JOINING MATERIALS

- A. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys.
- B. Threaded-Joint Tape: PTFE.

2.5 VALVES

- A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged in accordance with CGA G-4.1 for oxygen service.
- B. Ball Valves:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Amico Corporation.
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - c. BeaconMedaes.
 - d. Marwin Valve; Richards Industries.
 - e. NIBCO INC.
 - f. Ohio Medical Corporation.
 - g. Oxequip Health Industries; a division of Allied Healthcare Products Inc.
 - h. Tri-Tech Medical.
 2. Standard: MSS SP-110.
 3. Description: Three-piece body, brass, or bronze.
 4. Pressure Rating: 300 psig minimum.
 5. Ball: Full-port, chrome-plated brass.
 6. Seats: PTFE or TFE.
 7. Handle: Lever type with locking device.
 8. Stem: Blowout proof with PTFE or TFE seal.
 9. Ends: Manufacturer-installed ASTM B819, copper-tube extensions.
 10. Positive-pressure medical air valves shall be manufacturer cleaned, purged, and sealed as for oxygen service, in accordance with CGA G-4.1.
 - a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.
- C. Check Valves:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Amico Corporation.
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - c. BeaconMedaes.
 - d. Marwin Valve; Richards Industries.

- e. NIBCO INC.
 - f. Ohio Medical Corporation.
 - g. Oxequip Health Industries; a division of Allied Healthcare Products Inc.
 - h. Tri-Tech Medical.
- 2. Description: In-line pattern, bronze.
 - 3. Pressure Rating: 300 psig minimum.
 - 4. Operation: Spring loaded.
 - 5. Ends: Manufacturer-installed, ASTM B819, copper-tube extensions.
 - 6. Positive-pressure compressed-air valves shall be manufacturer cleaned, purged, and sealed as for oxygen service, in accordance with CGA G-4.1.
 - a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

D. Gas Safety Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Amico Corporation.
 - b. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - c. CEODEUX Meditec.
 - d. UCSF Health Environment of Care.
- 2. Bronze body.
- 3. ASME-construction, poppet, pressure-relief type.
- 4. Settings to match system requirements.
- 5. Positive-pressure compressed-air valves shall be manufacturer cleaned, purged, and sealed as for oxygen service, in accordance with CGA G-4.1.
 - a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

E. Compressed-Air Safety Valves:

- 1. Bronze body.
- 2. ASME-construction, poppet, pressure-relief type.
- 3. Settings to match system requirements.
- 4. Positive-pressure compressed-air valves shall be manufacturer cleaned, purged, and sealed as for oxygen service, in accordance with CGA G-4.1.
 - a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

F. Pressure Regulators:

- 1. Bronze body and trim.
- 2. Spring-loaded, diaphragm-operated, relieving type.
- 3. Manual pressure-setting adjustment.
- 4. Rated for 250-psig minimum inlet pressure.
- 5. Capable of controlling delivered air pressure within 0.5 psig for each 10-psig inlet pressure.

6. Positive-pressure medical air regulators shall be manufacturer cleaned, purged, and sealed as for oxygen service, in accordance with CGA G-4.1.
 - a. Valves shall be delivered sealed and labeled and kept sealed until prepared for installation.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. General Location and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install seismic restraints on compressed-air piping. Seismic-restraint devices are specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- C. Comply with NFPA 99 for installation of compressed-air piping.
- D. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.
- G. Install piping adjacent to equipment and specialties to allow service and maintenance.
- H. Install piping with 1 percent slope downward in direction of flow.
- I. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than system pressure rating used in applications specified in "Piping Schedule" Article unless otherwise indicated.
- J. Install eccentric reducers, if available, where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.
- K. Install branch connections to mains from top of main. Provide drain leg at end of each main and branch at low points.
- L. Install piping to permit valve servicing.
- M. Install piping free of sags and bends.
- N. Install fittings for changes in direction and for branch connections.

- O. Piping Restraint Installation: Install seismic restraints on compressed-air piping. Seismic-restraint devices are specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- P. Install service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.
- Q. Connect piping to air compressors and to compressed-air outlets and equipment requiring compressed-air service.
- R. Install unions in copper tubing adjacent to each valve and at final connection to each machine, specialty, and piece of equipment.
- S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.2 VALVE INSTALLATION

- A. Install shutoff valve at each connection to and from compressed-air equipment and specialties.
- B. Install check valves to maintain correct direction of compressed-air flow from compressed-air equipment.
- C. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.
- D. Install pressure regulators on compressed-air piping where reduced pressure is required.
- E. Install flexible pipe connectors in discharge of each air compressor.

3.3 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of cleaned tubing and fittings before assembly.
- C. Threaded Joints: Apply appropriate tape to external pipe threads.
- D. Brazed Joints: Join copper tube and fittings in accordance with CDA's "Copper Tube Handbook," Ch. "Brazed Joints." Do not use flux. Continuously purge joint with oil-free dry nitrogen during brazing.
- E. Extruded-Tee Outlets: Form branches in copper tube in accordance with ASTM F2014, with tools recommended by tube manufacturer.
- F. Flanged Joints:

1. Copper Tubing: Install flange on copper tubes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts in accordance with ASME B31.9 for bolting procedure.
- G. Shape-Memory-Metal Coupling Joints: Join new copper tube to existing tube according to procedures developed by fitting manufacturer for installation of shape-memory-metal coupling joints.
- 3.4 COMPRESSED-AIR SERVICE COMPONENT INSTALLATION
- A. Install compressed-air pressure-control panel in walls. Attach to substrate.
- 3.5 INSTALLATION OF HANGERS AND SUPPORTS
- A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- B. Comply with requirements for hangers, supports, and anchor devices specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
- C. Vertical Piping: MSS Type 8 or Type 42 clamps.
- D. Individual, Straight, Horizontal Piping Runs:
 1. 100 Feet and Less: MSS Type 1, adjustable, steel, clevis hangers.
 2. Longer Than 100 Feet: MSS Type 43, adjustable, roller hangers.
- E. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44 pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.
- F. Base of Vertical Piping: MSS Type 52 spring hangers.
- G. Install hangers for copper tubing with maximum horizontal spacing and minimum rod diameters to comply with MSS SP-58, NFPA 99, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- H. Support horizontal piping within 12 inches of each fitting and coupling.
- I. Support vertical runs of copper tubing to comply with MSS SP-58, NFPA 99, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- 3.6 IDENTIFICATION
- A. Install identifying labels and devices for compressed-air piping, valves, and specialties. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment."
- B. Install identifying labels and devices for medical compressed-air piping systems in accordance with NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:
 1. Compressed Air: Black letters on yellow-and-white checkerboard background.

3.7 FIELD QUALITY CONTROL FOR COMPRESSED-AIR PIPING

- A. Testing Agency: Engage qualified testing agency to perform tests and inspections of compressed-air piping and to prepare test and inspection reports.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections with the assistance of a factory-authorized service representative.
- D. Tests and Inspections:
 - 1. Piping Leak Tests for Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill compressed-air piping with oil-free dry nitrogen to pressure of 50 psig above system operating pressure, but not less than 150 psig. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
 - 2. Repair leaks and retest until no leaks exist.
- E. Piping will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.8 PROTECTION

- A. Protect tubing from damage.
- B. Retain sealing plugs in tubing, fittings, and specialties until installation.
- C. Clean tubing not properly sealed, and where sealing is damaged, in accordance with "Preparation" Article.

3.9 PIPING SCHEDULE

- A. Connect new tubing to existing tubing with memory-metal couplings.
- B. Flanges may be used where connection to flanged equipment is required.
- C. Compressed Air Piping, NPS 3 and Smaller Shall Operate between 15 psig and 50 psig: Type L copper tubing, wrought copper fittings and brazed joints.

3.10 VALVE SCHEDULE

- A. Shutoff Valves: Ball valve with manufacturer-installed ASTM B819, copper-tube extensions.

END OF SECTION

SECTION 22 61 19

COMPRESSED-AIR EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Scroll air compressors.
 - 2. Inlet-air filters.
 - 3. Desiccant compressed-air dryers.
 - 4. Compressed-air purification systems.
 - 5. Compressed-air filter assemblies.

1.3 DEFINITIONS

- A. Actual Air: Air delivered at air-compressor outlet. Flow rate is compressed air delivered and measured in acfm.
- B. Compressed Air Equipment: Compressed-air equipment and accessories for nonmedical facilities.
- C. Standard Air: Free air at 68 deg F and 1 atmosphere before compression or expansion and measured in scfm.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For air compressors, compressed-air dryers
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 - 4. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer and testing agency.
- B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For compressed-air equipment to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

- 1. Air-Compressor, Inlet-Air Filter Elements: Equal to 75% percent of quantity installed.
- 2. Belts: One for each belt-driven compressor.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications:

- 1. Compressed Air Equipment for Nonmedical Facilities: An employer of workers trained and approved by manufacturer.
- 2. Medical Air Equipment for Healthcare Facilities: Qualify installers according to ASSE 6010.

- B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the compressed-air equipment testing indicated, that is an NRTL and that is acceptable to authorities having jurisdiction.

- 1. Qualify testing personnel according to ASSE 6020 for inspectors and ASSE 6030 for verifiers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design compressed-air equipment mounting.

2.2 GENERAL REQUIREMENTS FOR AIR COMPRESSORS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty air compressors and receivers that deliver air of quality equal to intake air.
- C. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.
 - 1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.

2. Motor Controllers: Full-voltage, combination-magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
 3. Control Voltage: 120-V ac or less, using integral control power transformer.
 4. Motor Overload Protection: Overload relay in each phase.
 5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
 6. Automatic control switches to alternate lead-lag air compressors for duplex air compressors.
 7. Instrumentation: Include discharge-air and receiver pressure gages, air-filter maintenance indicator, hour meter, air-compressor discharge-air and coolant temperature gages, and control transformer.
 8. Alarm Signal Device: For connection to alarm system to indicate when backup air compressor is operating.
- D. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
1. Pressure Rating: At least as high as highest discharge pressure of connected air compressors and bearing appropriate code symbols.
 2. Interior Finish: Corrosion-resistant coating.
 3. Accessories: Include safety valve, pressure gage, automatic drain, and pressure regulator.
- E. Mounting Frame: Fabricate base and attachment to air compressor and components with reinforcement strong enough to resist movement during a seismic event when base is anchored to building structure.

2.3 SCROLL AIR COMPRESSORS

- A. Scroll Air Compressors:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Atlas Copco.
 - b. Ingersoll-Rand.
 - c. Quincy
 - d. Powerex
 - e. Kaeser
 2. Description: Packaged unit.
 3. Air Compressor(s): Single-stage, oil-free, rotary, oscillating-volute type of construction that prohibits oil from entering compression chamber.
 - a. Mounting: Freestanding.
- B. Capacities and Characteristics:
1. Refer to drawing schedules.
 2. Electrical Characteristics:
 - a. Volts: 460.
 - b. Phase(s): Three.

c. Hertz: 60.

3. Receiver: ASME construction steel tank.

- a. Orientation: Vertical arrangement.
- b. Capacity: 200 gal.
- c. Interior Finish: Epoxy
- d. Pressure Rating: 200 psig minimum.
- e. Pressure Relief Valve Setting: 126psig.
- f. Drain: Automatic valve.

2.4 INLET-AIR FILTERS

A. Description: Combination inlet-air filter-silencer, suitable for remote installation, for each air compressor.

- 1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
- 2. Capacity: Match capacity of air compressor, with collection efficiency of 99 percent retention of particles larger than 10 micrometers.

B. Description: Combination inlet-air filter-silencer, suitable for remote installation, for multiple air compressors.

- 1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
- 2. Capacity: Match total capacity of connected air compressors, with collection efficiency of 99 percent retention of particles larger than 10 micrometers.

2.5 COMPRESSED-AIR DRYERS

A. Desiccant Compressed-Air Dryers:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Atlas Copco.
 - b. Ingersoll-Rand
 - c. Quincy
 - d. Powerex
 - e. Kaeser
- 2. Description: Twin-tower unit with purge system, mufflers, and capability to deliver minus 40 deg F, 100-psig air at dew point. Include dew point controlled purge, step-down transformers, disconnect switches, inlet and outlet pressure gages, thermometers, automatic controls, and filters.

B. Capacities and Characteristics:

- 1. Refer to drawing schedules.
- 2. Electrical Characteristics:
 - a. Volts: 115.
 - b. Phase(s): Single.

- c. Hertz: 60.
- d. Full-Load Amperes: 10>.

2.6 COMPRESSED-AIR FILTER ASSEMBLIES

A. Compressed-Air Filter Assemblies <Insert drawing designation>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ingersoll-Rand.
 - b. Atlas Copco.
 - c. Quincy
 - d. Kaeser
2. Description: Filter assemblies suitable for compressed air, in parallel duplex arrangement. Size each assembly for maximum capacity of connected equipment and operating pressure of compressed-air system. Include automatic ejection of condensate from airstream, inlet and outlet pressure gages, and shutoff valves.
 - a. Option: Factory-fabricated filter system consisting of three air filters equivalent to those specified, pipe, fittings, valves, differential pressure switch, and enclosure; and with additional automatic drain traps and gages.
3. Size filter assemblies for 5-psig maximum air-pressure drop when filters are new and clean, at system rated capacity, and at 100-psig pressure.
4. Differential Pressure Switch: Adjustable, diaphragm type, with electrical connections for alarm system, to indicate when air-pressure drop through filters rises to more than 2 psig greater than when new and clean.
5. Particulate Filters: Collection efficiency of 98 percent retention of particles 1 micrometer and larger.
6. Coalescing Filters: Collection efficiency of 99.9 percent retention of particles 0.3 micrometer and smaller.
7. Include automatic drain trap for each filter.

2.7 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."

1. Enclosure: Totally enclosed, fan cooled.
2. Efficiency: Premium efficient.
3. Service Factor: 1.15
4. Electrical Characteristics:
 - a. Horsepower: Refer to drawing schedules
 - b. Volts: 460.
 - c. Phase: Three.
 - d. Hertz: 60.

PART 3 - EXECUTION

3.1 COMPRESSED-AIR EQUIPMENT INSTALLATION

- A. General Requirements for Compressed-Air Equipment Installation:
1. Install compressed-air equipment to allow maximum headroom unless specific mounting heights are indicated.
 2. Install equipment level and plumb, parallel, and perpendicular to other building systems and components in exposed interior spaces unless otherwise indicated.
 3. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
 4. Install equipment to allow right of way for piping installed at required slope.
 5. Install the following devices on compressed-air equipment:
 - a. Thermometer, Pressure Gage, and Safety Valve: Install on each compressed-air receiver.
 - b. Pressure Regulators: Install downstream from air compressors, dryers, purification units, and filter assemblies.
 - c. Drain Valves: Install on aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.
- B. Nonmedical Compressed-Air Equipment Installation:
1. Install compressed-air equipment, except wall-mounted equipment, on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 2. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."
 - a. Anchor air compressors to surface according to manufacturer's written instructions.

3.2 CONNECTIONS

- A. Comply with requirements for water-supply piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements for drain piping specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Comply with requirements for compressed-air piping specified in Section 226113 "Compressed-Air Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
- D. Where installing piping adjacent to equipment, allow space for service and maintenance.
- E. Connect compressed-air piping to compressed-air equipment, accessories, and specialties with shutoff valve and union or flanged connection.

- F. Connect water supply to compressed-air equipment that requires water. Include backflow preventer. Backflow preventers are specified in Section 221119 "Domestic Water Piping Specialties."

3.3 IDENTIFICATION

- A. Identify nonmedical compressed-air equipment system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check for lubricating oil in lubricated-type equipment.
 - 3. Check belt drives for proper tension.
 - 4. Verify that air-compressor inlet filters and piping are clear.
 - 5. Check for equipment vibration-control supports and flexible pipe connectors and verify that equipment is properly attached to substrate.
 - 6. Check safety valves for correct settings. Ensure that settings are higher than air-compressor discharge pressure, but not higher than rating of system components.
 - 7. Check for proper seismic restraints.
 - 8. Drain receiver tank(s).
 - 9. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 10. Test and adjust controls and safeties.
- B. Prepare written report documenting testing procedures and results.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air compressors, compressed-air dryers, and compressed-air filter assemblies.

END OF SECTION

SECTION 22 62 13

VACUUM PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Laboratory vacuum piping, designated "laboratory vacuum."
- B. Related Requirements:
 - 1. Section 226219 "Vacuum Equipment" for vacuum producers and accessories.

1.3 DEFINITIONS

- A. Vacuum Piping Systems: Include medical vacuum, WAGD, dental vacuum, HVE, and laboratory vacuum piping systems.
- B. Laboratory Vacuum Piping Systems: Include laboratory low-vacuum and laboratory high-vacuum piping systems.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer and testing agency.
- B. Material Certificates: Signed by Installer, certifying that medical vacuum piping materials comply with requirements in NFPA 99 for medical vacuum systems.
- C. Brazing certificates.
- D. Field quality-control reports.
- E. Source Quality Control Reports:

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For vacuum piping specialties to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Pressure-Seal Joining Procedure for Copper Tubing: An authorized representative who is trained and approved by manufacturer.
- B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum piping testing indicated, that is an NRTL, and that is acceptable to authorities having jurisdiction.
 - 1. Qualify testing personnel in accordance with ASSE Standard #6020
- C. Brazing: Qualify processes and operators in accordance with ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications," or AWS B2.2/B2.2M.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Laboratory vacuum operating at 25 in. Hg.

2.2 PIPES, TUBES, AND FITTINGS

- A. Copper Water Tube: ASTM B88/ASTM B88M, Type K, seamless, drawn temper.
- B. Wrought-Copper Fittings: ASME B16.22, brazed-joint pressure type that has been manufacturer cleaned, purged, and sealed for medical gas service or in accordance with CGA G-4.1 for oxygen service.
- C. Copper Unions: ASME B16.22 or MSS SP-123, wrought-copper or cast-copper alloy.
- D. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150.
 - 1. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness, full-face type.
 - 2. Flange Bolts and Nuts: ASME B18.2.1 carbon steel.
- E. Pressure-Seal Fittings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. NIBCO INC.
 - b. Viega LLC.
 - 2. NPS 2 and Smaller: Wrought-copper fitting with EPDM O-ring seal in each end.

3. NPS 2-1/2 to NPS 4: Bronze fitting with stainless steel grip ring and EPDM O-ring seal in each end.

F. Flexible Pipe Connectors:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flex-Hose Co., Inc.
 - b. Flexicraft Industries.
 - c. Hyspan Precision Products, Inc.
 - d. Mercer Rubber Co.
 - e. Metraflex Company (The).
 - f. Proco Products, Inc.
 - g. Universal Metal Hose.
2. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
 - a. Working-Pressure Rating: 200 psig minimum.
 - b. End Connections: Plain-end copper tube.

2.3 JOINING MATERIALS

- A. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys.
- B. Threaded-Joint Tape: PTFE.

2.4 VALVES

- A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged in accordance with CGA G-4.1 for oxygen service.
 1. Exception: Factory cleaning and bagging are not required for valves for WAGD service.
- B. Ball Valves:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Healthcare Products Inc.
 - b. Amico Corporation.
 - c. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - d. BeaconMedaes.
 - e. Marwin Valve; Richards Industries.
 - f. NIBCO INC.
 - g. Ohio Medical Corporation.
 - h. Tri-Tech Medical.
 2. Standard: MSS SP-110.
 3. Description: Three-piece body, brass or bronze.
 4. Pressure Rating: 300 psig minimum.
 5. Ball: Full-port, chrome-plated brass.

6. Seats: PTFE or TFE.
 7. Handle: Lever type with locking device.
 8. Stem: Blowout proof with PTFE or TFE seal.
 9. Ends: Manufacturer-installed ASTM B819, copper-tube extensions.
- C. Check Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Healthcare Products Inc.
 - b. Amico Corporation.
 - c. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - d. BeaconMedaes.
 - e. Marwin Valve; Richards Industries.
 - f. NIBCO INC.
 - g. Ohio Medical Corporation.
 - h. Tri-Tech Medical.
 2. Description: In-line pattern, bronze.
 3. Pressure Rating: 300 psig minimum.
 4. Operation: Spring loaded.
 5. Ends: Manufacturer-installed ASTM B819, copper-tube extensions.
- D. Vacuum Bottle Brackets: One piece, with pattern and finish matching corresponding service cover plate.
- E. Cover Plates:
1. One piece.
 2. Aluminum or stainless steel.
 3. Permanent, color-coded, identifying label matching corresponding service.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. General Location and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of vacuum piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, vacuum producer sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Comply with NFPA 99 for installation of vacuum piping.
- C. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.
- F. Install piping adjacent to equipment and specialties to allow service and maintenance.
- G. Install piping with 1 percent slope downward in direction of flow.
- H. Install nipples, unions, special fittings, and valves with pressure ratings same as or higher than piping pressure rating used in applications specified in "Piping Schedule" Article unless otherwise indicated.
- I. Install eccentric reducers, if available, where vacuum piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.
- J. Provide drain leg and drain trap at end of each main and branch and at low points.
- K. Install piping to permit valve servicing.
- L. Install piping free of sags and bends.
- M. Install fittings for changes in direction and for branch connections. Extruded-tee branch outlets in copper tubing may be made where specified.
- N. Install medical vacuum piping from medical vacuum service connections specified in this Section, to equipment specified in Section 226219 "Vacuum Equipment for Laboratory and Healthcare Facilities," and to equipment specified in other Sections requiring medical vacuum service.
- O. Install vacuum service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.
- P. Install vacuum bottle bracket adjacent to each wall-mounted medical vacuum service connection suction inlet.
- Q. Connect vacuum piping to vacuum producers and to equipment requiring vacuum service.
- R. Install unions in copper vacuum tubing adjacent to each valve and at final connection to each machine, specialty, and piece of equipment.
- S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.2 VALVE INSTALLATION

- A. Install shutoff valve at each connection to and from vacuum equipment and specialties.
- B. Install check valves to maintain correct direction of vacuum flow to vacuum-producing equipment.

- C. Install valve boxes recessed in wall and anchored to substrate. Single boxes may be used for multiple valves that serve same area or function.
- D. Install zone valves and gages in valve boxes. Rotate valves to angle that prevents closure of cover when valve is in closed position.
- E. Install flexible pipe connectors in suction inlet piping to each vacuum producer.

3.3 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints: Apply appropriate tape to external pipe threads.
- D. Brazed Joints: Join copper tube and fittings in accordance with CDA's "Copper Tube Handbook," Ch. "Brazed Joints." Do not use flux. Continuously purge joint with oil-free dry nitrogen during brazing.
- E. Flanged Joints:
 - 1. Copper Tubing: Install flange on copper tubes. Use pipe-flange gasket between flanges. Join flanges with gasket and bolts in accordance with ASME B31.9 for bolting procedure.
- F. Pressure-Sealed Joints: Join copper tube and copper and copper-alloy fittings with tools recommended by fitting manufacturer.

3.4 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- B. Comply with requirements for hangers, supports, and anchor devices specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
- C. Vertical Piping: MSS Type 8 or Type 42, clamps.
- D. Individual, Straight, Horizontal Piping Runs:
 - 1. 100 Feet and Less: MSS Type 1, adjustable, steel, clevis hangers.
 - 2. Longer Than 100 Feet: MSS Type 43, adjustable, roller hangers.
- E. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44 pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.
- F. Base of Vertical Piping: MSS Type 52 spring hangers.
- G. Install hangers for copper tubing with maximum horizontal spacing and minimum rod diameters to comply with MSS SP-58, NFPA 99, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

- H. Support horizontal piping within 12 inches of each fitting and coupling.
- I. Support vertical runs of copper tubing to comply with MSS SP-58, NFPA 99, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.5 IDENTIFICATION

- A. Install identifying labels and devices for laboratory vacuum piping, valves, and specialties. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment."
- B. Install identifying labels and devices for medical vacuum piping systems in accordance with NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:
 - 1. Laboratory Vacuum: Black boxed letters on white-and-black checkerboard background.

3.6 FIELD QUALITY CONTROL FOR LABORATORY FACILITY VACUUM PIPING

- A. Testing Agency: Engage qualified testing agency to perform tests and inspections of vacuum piping in laboratory facilities and to prepare test and inspection reports.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections with the assistance of a factory-authorized service representative.
- D. Tests and Inspections:
 - 1. Piping Leak Tests for Vacuum Piping: Test new and modified parts of existing piping. Cap and fill vacuum piping with oil-free, dry nitrogen. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
 - a. Test Pressure for Copper Tubing: 150 psig.
 - 2. Repair leaks and retest until no leaks exist.
 - 3. Inspect filters for proper operation.
- E. Piping will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.7 PROTECTION

- A. Protect tubing from damage.
- B. Retain sealing plugs in tubing, fittings, and specialties until installation.

- C. Clean tubing not properly sealed, and where sealing is damaged, in accordance with "Preparation" Article.

3.8 PIPING SCHEDULE

- A. Connect new copper tubing to existing copper tubing with memory-metal couplings.
- B. Connect PVC pipe to copper tube with transition fittings.
- C. Flanges may be used where connection to flanged equipment is required.
- D. Laboratory Vacuum Piping: Use the following piping materials for each size range:
 - 1. NPS 4 and Smaller: Copper medical gas tube, wrought-copper fittings, and brazed joints.
 - 2. NPS 5 to NPS 8: Copper medical gas tube, wrought-copper fittings, and brazed joints.

3.9 VALVE SCHEDULE

- A. Shutoff Valves:
 - 1. Copper Tubing: Copper-alloy ball valve with manufacturer-installed ASTM B819, copper-tube extensions.
- B. Zone Valves: Copper-alloy ball valve with manufacturer-installed ASTM B819, copper-tube extensions with pressure gage on one copper-tube extension.

END OF SECTION

SECTION 22 62 19

VACUUM EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Rotary, sliding-vane vacuum pumps.

1.3 DEFINITIONS

- A. Actual Air: Air delivered at vacuum producer inlet. Flow rate is air measured in acfm.
- B. HVE: High-volume oral evacuation for dental applications in healthcare facilities.
- C. Laboratory Vacuum Equipment: Vacuum producers and accessories for nonmedical laboratory facilities.
- D. Standard Air: Free air at 68 deg F and 1 atmosphere before compression or expansion and measured in scfm.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For vacuum producers.
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 - 4. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer and testing agency.
- B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For vacuum equipment to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

- 1. Belts: One for each belt-driven vacuum producer.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications:

- 1. Laboratory Vacuum Equipment for Nonmedical Laboratory Facilities: An employer of workers trained and approved by manufacturer.

- B. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum equipment testing indicated, that is acceptable to authorities having jurisdiction.

- 1. Qualify testing personnel according to ASSE 6020 for inspectors and ASSE 6030 for verifiers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vacuum equipment mounting.

2.2 GENERAL REQUIREMENTS FOR VACUUM PUMPS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty vacuum pumps and receivers.
- C. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.
 - 1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
 - 2. Motor Controllers: Full-voltage, combination-magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
 - 3. Control Voltage: 120-V ac or less, using integral control power transformer.
 - 4. Motor Overload Protection: Overload relay in each phase.
 - 5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.

6. Automatic control switches to alternate lead-lag vacuum pumps for duplex vacuum pumps.
 7. Instrumentation: Include vacuum pump inlet and receiver vacuum gages, hour meter, vacuum pump discharge-air and coolant temperature gages, and control transformer.
 8. Alarm Signal Devices: For connection to alarm system to indicate when backup vacuum pump is operating.
- D. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code, Section VIII, Division 1; bearing appropriate code symbols.
1. Interior Finish: Corrosion-resistant coating.
 2. Accessories: Include vacuum relief valve, vacuum gage, and drain.
- E. Mounting Frames: Fabricate base and attachment to vacuum pump and components with reinforcement strong enough to resist movement during a seismic event when base is anchored to building structure.

2.3 ROTARY, SLIDING-VANE VACUUM PUMPS

A. Oil-Sealed, Rotary, Sliding-Vane Vacuum Pumps:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BeaconMedaes.
 - b. Busch USA
2. Description: Packaged unit.
3. Vacuum Pumps: Nonpulsating, oil-sealed, rotary, sliding-vane type.
 - a. Cleanable inlet screens.
 - b. Outlet silencers and oil-mist separators on discharge connections.
4. Receiver: ASME construction steel tank with vacuum relief valve.

B. Capacities and Characteristics:

1. Vacuum Service: Refer to drawing schedules
2. Electrical Characteristics:
 - a. Volts: 460.
 - b. Phase(s): Three.
 - c. Hertz: 60.

PART 3 - EXECUTION

3.1 VACUUM EQUIPMENT INSTALLATION

- A. Install vacuum equipment for healthcare facilities according to ASSE 6010 and NFPA 99.

B. Equipment Mounting:

1. Install vacuum producers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

C. Install vacuum equipment anchored to substrate.

D. Orient equipment so controls and devices are accessible for servicing.

E. Maintain manufacturer's recommended clearances for service and maintenance.

F. Install the following devices on vacuum equipment:

1. Thermometer, Vacuum Gage, and Pressure Relief Valve: Install on each vacuum pump receiver.
2. Drain Valves: Install on receivers and separators. Discharge receiver condensate over nearest floor drain. Discharge separator or air evacuation fluids by direct connection into sanitary waste piping system.

3.2 CONNECTIONS

- A. Comply with requirements for water-supply piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements for drain piping specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Comply with requirements for vacuum piping specified in Section 226213 "Vacuum Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- D. Where installing piping adjacent to equipment, allow space for service and maintenance.
- E. Connect vacuum piping to vacuum equipment, accessories, and specialties with shutoff valve and union or flanged connection.
- F. Connect water supply to vacuum equipment that requires water. Include backflow preventer. Backflow preventers are specified in Section 221119 "Domestic Water Piping Specialties."

3.3 IDENTIFICATION

- A. Identify nonmedical laboratory vacuum equipment system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL FOR VACUUM EQUIPMENT

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Vacuum Equipment Testing Coordination: Perform tests, inspections, verifications, and certification of vacuum equipment concurrently with tests, inspections, and certification of vacuum piping systems.
 - 2. Preparation: Perform vacuum equipment tests according to requirements in NFPA 99 for the following:
 - a. System operation test.
 - 3. Equipment Verification: Comply with requirements in ASSE 6020, ASSE 6030, and NFPA 99 for verification of vacuum equipment.
 - 4. Replace damaged and malfunctioning controls and equipment.
 - 5. Testing Certification: Certify that specified tests, inspections, and procedures have been performed and certify report results. Include the following:
 - a. Inspections performed.
 - b. Procedures and materials used.
 - c. Test methods used.
 - d. Results of tests.
- D. Components will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check for lubricating oil in lubricated-type equipment.
 - 3. Check belt drives for proper tension.
 - 4. Verify that vacuum producer outlet piping is clear.
 - 5. Check for equipment vibration-control supports and flexible pipe connectors and verify that equipment is properly attached to substrate.
 - 6. Check safety valves for correct settings.
 - 7. Drain receiver and separator tank(s).
 - 8. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 9. Test and adjust controls and safeties.
- B. Verify that vacuum equipment is installed and connected according to the Contract Documents.
- C. Verify that electrical wiring installation complies with manufacturer's submittal and written installation requirements in electrical Sections.
- D. Prepare written report documenting testing procedures and results.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain vacuum producers.

END OF SECTION

SECTION 22 66 00

CHEMICAL WASTE SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Single-wall piping.
 - 2. Double-containment piping.
 - 3. Field-fabrication containment piping.
 - 4. Piping specialties.
 - 5. Neutralization systems.
 - 6. Leak-detection systems.

1.3 DEFINITIONS

- A. FPM: Vinylidene fluoride (hexafluoropropylene copolymer rubber).

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For neutralization system and leak-detection system.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of neutralization-system assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include details of leak-detection-system assemblies. Indicate required clearances, method of field assembly, components, and location and size of each field connection.
 - 4. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Pipe sizes, locations, and elevations.
 - 2. Other piping in same trench and clearances from sewerage system piping.
 - 3. Interface and spatial relationship between piping and proximate structures.
- B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For chemical-waste specialties and neutralization tanks neutralization systems and leak-detection systems to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Neutralization-System Limestone and Chemicals: For each neutralization system.
 - a. Chemicals: Equal to 500 percent of neutralizing chemicals required for filling tanks.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store piping and specialties with sealing plugs in ends or with end protection.
- B. Do not store plastic pipe or fittings in direct sunlight.
- C. Protect pipe, fittings, and seals from dirt and damage.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 70.

2.2 PERFORMANCE REQUIREMENTS

- A. Single-Wall Piping Pressure Rating: 5-psig.
- B. Double-Containment Piping Pressure Rating:
 - 1. Carrier Piping: 5-psig air test pressure to 10 feet head of water for 30 minutes.
 - 2. Containment Piping: 5-psig air test pressure to 10 feet head of water for 30 minutes.
- C. Field-Fabrication Containment-Piping Pressure Rating: 5-psig air test pressure to 10 feet head of water for 30 minutes.

2.3 SINGLE-WALL PIPE AND FITTINGS

- A. PP Drainage Pipe and Fittings: ASTM F1412, extruded pipe and drainage-pattern fittings molded, with Schedule 40 dimensions and with fire-retardant additive complying with ASTM D4101; with fusion--joint ends.

1. Exception: Pipe and fittings made from PP resin without fire-retardant additive may be used for underground installation.
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. GF Piping Systems: Georg Fischer LLC.
 - b. IPEX USA LLC.
 - c. Orion Fittings; A WATTS Brand.
 - d. Town & Country Plastics, Inc.
 - e. Zurn Industries, LLC.
 3. Source Limitations: Obtain pipe and fittings from single source from single manufacturer.
- B. Adapters and Transition Fittings: Assemblies with combinations of clamps, couplings, adapters, and gaskets; compatible with piping and system liquid; made for joining different piping materials.

2.4 DOUBLE-CONTAINMENT PIPE AND FITTINGS

- A. Description: Factory-fabricated, double-wall pipe and fittings. Sizes indicate carrier-pipe size; with carrier (inner) pipe and fittings; annular-space, carrier-pipe supports; containment (outer) pipe and fittings; and joining materials and fasteners.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Asahi/America.
 2. Flo Safe, Inc.
 3. GF Piping Systems: Georg Fischer LLC.
 4. Insul-Tek Piping Systems, Inc.
 5. IPEX USA LLC.
 6. Orion Fittings; A WATTS Brand.
 7. Performance Pipe.
- C. Source Limitations: Obtain pipe and fittings from single source from single manufacturer.
- D. Piping Materials:
1. PP Double-Containment Drainage Pipe and Fittings: Made of ASTM D4101 PP resin.
 - a. Carrier and Containment Pipes: ASTM F1412, Schedule 40.
 - b. Fittings: ASTM F1412, Schedule 40 drainage pattern complying with ASTM D3311.
- E. Include design and fabrication of double-containment pipe and fitting assemblies with provision for field installation of cable leak-detection system in annular space between carrier and containment piping.

2.5 FIELD-FABRICATION CONTAINMENT PIPING

- A. Description: Containment split pipe and split fittings with carrier-pipe centralizers. Include manufacturer's fastening devices and materials.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Flo Safe, Inc.
 - 2. GF Piping Systems: Georg Fischer LLC.
- C. Source Limitations: Obtain containment piping from single source from single manufacturer.
- D. Material PP pipe and fittings.
- E. Fastening System: FPM gaskets, clamps, and pins.

2.6 JOINING MATERIALS

- A. Couplings: Assemblies with combinations of clamps, gaskets, sleeves, and threaded or flanged parts; compatible with piping and system liquid; and made by piping manufacturer for joining system piping.
- B. Adapters and Transition Fittings: Assemblies with combinations of clamps, couplings, adapters, gaskets, and threaded or flanged parts; compatible with piping and system liquid; and made for joining different piping materials.
- C. Flanges: Assemblies of companion flanges and gaskets complying with ASME B16.21 and compatible with system liquid, and bolts and nuts.

2.7 PIPING SPECIALTIES

- A. Corrosion-Resistant Traps:
 - 1. Type: P-trap or drum trap.
 - 2. Size: NPS 1-1/2 or NPS 2, as required to match connected piping.
 - 3. High-Silicon Iron: ASTM A861, with horizontal outlet and hub-and-plain or plain ends to match connecting piping.
 - 4. PP: ASTM D4101, with mechanical-joint pipe connections.
 - 5. PVDF: ASTM D3222, with mechanical-joint pipe connections.
 - 6. Glass: ASTM C1053, with coupling pipe connections.
- B. Stainless Steel Floor Drains:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. Sioux Chief Manufacturing Company, Inc.
 - 2. Source Limitations: Obtain floor drains from single source from single manufacturer.
 - 3. Standard: ASME A112.3.1; ASTM A666, Type 316L.

4. Body: With 8.5-by-8.5-inch top with grate.
5. Outlet: Bottom, of size indicated.

C. PP Floor Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. GF Piping Systems: Georg Fischer LLC.
 - b. IPEX USA LLC.
 - c. Orion Fittings; A WATTS Brand.
 - d. Schier Products Company.
 - e. Town & Country Plastics, Inc.
 - f. WATTS.
 - g. Zurn Industries, LLC.
2. Source Limitations: Obtain floor drains from single source from single manufacturer.
3. Body: With 7- to 9-inch top diameter, with flashing flange and weep holes; and with flashing clamp trap-primer connection.
4. Outlet: Bottom, to match connecting pipe, with NPS 2, NPS 3, NPS 4, or NPS 6 outlet as indicated.

D. Stainless Steel Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. Sioux Chief Manufacturing Company, Inc.
2. Source Limitations: Obtain cleanouts from single source from single manufacturer.
3. Standard: ASME A112.3.1; ASTM A666, Type 316L.
4. Aboveground Piping: Cleanout tee of size matching piping.
5. Underground and Underslab Piping: Floor access cleanout of size matching piping.

E. Plastic Backwater Valves:

1. Description: Full-port NPS 3 check valve, PP or PVDF, matching or compatible with system piping and compatible with system liquid, with EPDM seals and flanged ends.
 - a. Exception: PVC material for use with PVC piping systems.

F. PP Sink Outlets:

1. Description: NPS 1-1/2, with clamping device, stopper, and 7-inch-high overflow fitting.

2.8 NEUTRALIZATION SYSTEMS

- A. The laboratory waste pH Neutralization System shall be supplied as a complete,

integrated process system by a single supplier, skid mounted, preassembled and pretested prior to delivery to the site. The system shall be delivered as a complete skid with all inter connecting piping, signal wiring, and power wiring installed and tested prior to delivery. The system shall be manufactured by Practical Applications, Inc.

- B. The laboratory waste pH Neutralization system shall be a two-stage system with two continuous, stirred tank reactors in series. Each tank stage shall have bi-directional pH control and have equal treatment capacity in order to provide full redundancy. Laboratory waste shall flow into the first tank from the laboratory drain system. After mixing and treatment, the wastewater shall flow into the second tank for additional treatment as necessary and then be discharged to the sewer. The pH of the final treated effluent wastewater shall be monitored independently and shall be recorded on a circular chart recorder. The flow rate and total cumulative flow of the final treated effluent shall be monitored and shall be recorded on the same circular chart recorder.

C. Equipment Specifications

1. Reactor Tanks 400 gallons working capacity

Quantity:	Two (2)
Volume:	300 gallons to invert
Dimensions:	Height and Width should be 1:1 ratio to tank operating capacity and provide at least 6" of free board.
Material:	Polypropylene
Wall Thickness:	1/2" Minimum
Baffles:	Sufficiently baffle to prevent mixer vortexing
Nozzles:	4" Inlet Flange, 4" Outlet Flange, 3" Vent Flange
Cover:	3/4" Minimum thickness to support 250 lbs. and provide an 18" man-way
Seals:	The tank is required to operate air tight and all seals must meet a 10 foot hydrostatic test.
2. Chemical Storage Tanks and Dispensing

Quantity:	two (2) acid and base
Type:	Integral spill containment and suction piping
Volume:	provide a total of 30 gallons each
Material:	compatible with sulfuric acid (98%) and sodium hydroxide (50%)
Configuration:	Provide chemical dispensing from DOT shipping containers to eliminate chemical refilling via

pumping. The suction shall be rigid in the drum and flexible between the drum bung and the pump suction. The DOT shipping container shall be fitted with a low level sensor for alarm. Both the suction fixture and the level sensor fixture shall be adjustable to accommodate various drum types and be threaded with a buttress thread.

Reagent Pump

Mounting: The reagent pumps shall be mounted on a support separate from the storage tanks and shall be free standing and constructed of corrosion resistant materials.

Secondary

Containment: Provide separate secondary containment for all both acid and base reagent pump discharge piping in a 1.5" PVC conduit. The containment piping will begin 6" from the pump discharge and will terminate 6" prior to the tank connection. Also provide separate spill containment, acid and base, for 110% of the largest drum.

3. Mixers for Neutralization Tanks

Quantity: Two (2)

Type: Gear-reduced, continuous duty

Motor: 3/4 HP TEFC Motor 230/460 Volts, 3 phase

Shaft Seal: 3"/150# ANSI flange with integral stuffing box (6 psi)

Shaft/Impeller: 3/4" Diameter Shaft, 8" impeller, 316 SS

Manufacturer: Practical Applications, Inc.

Model: TW-2000-050

Mixer shall be mounted to seal with the tank cover and shall be supported separately by an epoxy coated steel structure or with a corrosive resistant material which distributes the weight to the tank side walls.

4. Metering Pumps

Quantity: Four (4)

Type: Electronically controlled, solenoid actuated, single diaphragm positive displacement pump

Motor: 120 VAC

Capacity: 20 GPH (minimum each pump)

Manufacturer: Liquid Metronics Inc.

Model: LMI C941-34

5. pH Analyzers and Sensors

Quantity: Three (3) Tank 1, Tank 2, Effluent

Analyzer Type: Single or dual inputs; simultaneously displays both readouts on a backlit display along with a 16-character information, NEMA 4X panel mount; Outputs, two (2) Isolated 4-20 mA, three (3) electromechanical relays; Sensor calibration with software via touch pad.

Sensor Type: Combination electrode, temp. range 0 - 100°C, max. press: 90 psig, measuring range: 0 to 14 pH, wetted materials: PPS (Ryton) or PVDF (Kynar) body, PTFE junction, glass process electrode, 30 ft long 5 conductor (plus shield) cable

Sensor Fixture: Hot Tap Style, removable from tank sidewall, 316 SS construction. Top entry fixtures are not accepted.

Power: 120 VAC, 60 Hz

Manufacturer: ABB, Inc.

Model: ABB Model AX46650001 Dual Input pH Analyzer, ABB Model AX46050001 Single Input pH Analyzer, ABB Model AP30311010001 pH Sensor

6. Flow Meter and Transmitter

Quantity: One (1)

Type: Low frequency Electromagnetic induction type and shall produce a DC pulse signal directly proportional and linear to the liquid flowrate

Power: 120 VAC, 60 Hz

Size: 4 inch

Housing: Carbon Steel; The meter housing shall be NEMA 4X as standard with an option for accidental submergence in up to 30 feet of water for up to 48 hours without damage to the

electronics.

Mounting: 150# Carbon Steel Flange

Electrode Material: 316 Stainless Steel

Liner: Teflon®

Output: Flow Transmitter shall provide a pulse output directly proportional to the volume discharged. A Flow Proportional Signal Cable shall be provided for connection to industry samplers.

Manufacturer: ABB

Model: 10DX3111EDE17P1B2BA1132105/Transmitter
Model# 50XM13NXAD22AA229

7. Chart Recorder

Quantity: One (1)

Type: Chart Recorder - 7 Day - pH / Flow / Time
Monitoring/Totalizer

Number of Inputs: Two (2)

Chart: Self Generating

Case & Mounting: NEMA 4X & Panel

Input Type: 4-20 mA

Manufacturer: ABB

Model: SM500F

8. Main Control Panel

The control panel shall be UL listed, wall mounted, NEMA 4 enclosure, sized to adequately house all necessary instrumentation, fuses, control circuit transformer, circuit breakers, and motor starters, etc. The panel shall be mounted within the pH neutralization System footprint and at a height suitable for accessibility. The panel will include all interconnecting wiring to the pH Sensors and Analyzers, Circular Chart Recorder, Chemical Metering Pumps, Mixers, and alarms. All pre-wiring shall be done in PVC jacketed flexible conduit for a complete NEMA 4 system. Panel will have alarms contacts to connect with a building supervisory remote alarm system. One disconnect shall de-energize all power to the pH Neutralization System.

The panel shall incorporate ON/OFF 2—position selector switches with green pilot lights to indicate operational status and provide control of Mixers, System Power, and Chemical Metering Pumps (one each). The

panel will include an audible alarm and push button alarm "Silence". The pH Analyzers and Circular Chart Recorder will be mounted through the panel door giving routine access to the settings or maintenance required for Recording/Controlling the pH Neutralization System process. The Flow Transmitter shall be field mounted within the pH Neutralization System footprint.

Alarm Points: The control panel shall incorporate an audible alarm, red pilot lights, and dry contacts for connection to a remote alarm (by others). Each alarm condition shall have its own individual red pilot light. Dry alarm contacts will be provided for connection by others to an existing, remote alarm panel. Each Dry Alarm contact shall be rated for 10 A 120 VAC. An alarm shall be provided in response to the following process conditions; Effluent pH Out-of-Spec, Low Level Acid Reagent Tank 1, Low Level Acid Reagent Tank 2, Low Level Base Reagent Tank 1, Low Level Base Reagent Tank 2, pH Analyzer/Sensor Fault Status, General Trouble.

External panel connectors and cable outlets shall be rated for a NEMA 4 environment. All instruments shall be identified by black and white engraved, laminated nameplates. Lettering shall be 3/8" high, minimum. The instrument panel shall be arranged to give an orderly presentation of the instrumentation. The enclosure shall have a hinged panel that provides ready access to all instruments and accessories for servicing. All items shall be so wired and mounted that, in general, any one item can be removed without interruption of the other items. No zero-based analog signals shall be used between instruments. All instruments shall be mounted semi-flush on the front of the panel in a manner such that all basic controls and adjustments are accessible without unlatching or opening the panel itself. The following connections will be provided to the building supervisory system, as an option, as isolated signals: General Trouble (digital), pH Tank 1 (analog), pH Tank 2 (analog), Effluent pH (analog), and Effluent Flow (analog).

D. Installation

Furnish the services of the manufacture's engineering representative for checking the installation, making the necessary adjustments and calibrations, placing the equipment in operation, and performing the acceptance tests. The representative shall be completely familiar with the pH Neutralization System and shall be available for not less than 1 day to instruct operating personnel in the use, operation, and maintenance of the equipment during the initial operating period. Install all pH Neutralization System equipment in accordance with the recommendations of the manufacturer

E. Startup and Training

Supplier shall provide one (1) day of supervised pH Neutralization System start-up and operation oversight. During this time, a factory authorized technician familiar with the pH Neutralization System shall instruct the owner regarding start-up, operation and routine maintenance. This instruction shall be consistent with information provided in the pH Neutralization Systems Operation and Maintenance (O&M) Manual. All instrumentation shall be calibrated with the owners personnel present. Supplier shall provide a minimum of 30 gallons of each reagent for startup, reagent should be mercury free technical grade.

F. Operation and Maintenance Manuals

Three (3) copies of Operation and Maintenance (O& M) Manual specifically written for the pH Neutralization System shall be included and will completely describe the installation, operation and maintenance of the System and all of its associated components. Furnish one complete manual prior to the time that equipment tests are performed, and furnish the remaining manuals before the contract is completed. The manual shall include: wiring and control diagrams with data to explain detailed operation and control of each item of equipment; a control sequence describing start-up, operation and shut-down; description of the function of each principal item of equipment; the procedure for starting; the procedure for operating; shut-down instructions; installation instructions; maintenance instructions; lubrication schedule including type, grade, temperature range, and frequency; safety precautions, diagrams, and illustrations; test procedures; performance data; and parts list. The following equipment shall be included in the O&M Manual; pH Analyzer/Monitor, pH Sensor, Chemical Metering Pumps, Back Pressure Valves, Mixers, Flow Meter, Flow Transmitter, Circular Chart Recorder, Piping, Valves, Tanks, Chemical Dispensing Drums & Equipment, Flow Proportional Signal Cable.

G. Engineering Drawings

Drawings shall be a minimum of 17-inches by 22-inches in size, except as specified otherwise. Three (3) sets of shop drawings shall be submitted. Drawings shall include floor plans, sectional views, wiring diagrams, and installation details of equipment; and equipment spaces identifying and indicating proposed location, layout and arrangement of items of equipment, control panels, accessories, piping, ductwork, and other items that must be shown to assure a coordinated installation. Wiring diagrams shall identify circuit terminals, and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. If equipment is disapproved, drawings shall be revised to show acceptable equipment and be resubmitted.

The engineering drawings at a minimum will consist of the following; Title Page - (Including Site Plan), Piping & Instrumentation Diagram, Mechanical Drawing - Plan and Section Views (Inc. Bills of Materials), Electrical Drawing - Power and Control Logic (Inc. Bills of Materials).

H. Guarantee

All electrical and mechanical equipment shall carry the original manufacturer's warranty. Supplier shall warrant the pH Neutralization System free from fabrication defects for a period of one year from date of shipment.

2.9 LEAK-DETECTION SYSTEMS

A. Leak-Detection Systems.

1. Description: Cable leak-detection system capable of detecting and annunciating fluid leaks; with controls, panel, wiring, cable sensors, probes if required, and piping.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Asahi/America.
 - b. Flo Safe, Inc.
 - c. IPEX USA LLC.
 - d. Pentair Thermal Management.
 - e. Perma-Pipe, Inc.
3. Source Limitations: Obtain leak-detection systems from single source from single manufacturer.
4. Annunciator Panel: Enclosure with visual and audible alarms and leak-location indicator.
5. Sensors: Electric cable, suitable for insertion in double-containment piping annular space, with capability of detecting fluid leaks and signaling locations of leaks.

PART 3 - EXECUTION

3.1 CONCRETE BASES

A. Equipment Mounting:

1. Install neutralization system tanks on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."

B. Anchor neutralization system tanks to concrete bases.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 19-inch centers around full perimeter of base.
2. For installed equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be imbedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

3.2 PIPING INSTALLATION

A. Chemical-Waste Piping Inside the Building:

1. Install piping adjacent to equipment, accessories, and specialties, to allow space for service and maintenance.
2. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used unless otherwise indicated.
3. Flanges may be used on aboveground piping unless otherwise indicated.
4. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
5. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
6. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
7. Install piping at indicated slopes.

8. Install piping free of sags and bends.
9. Install fittings for changes in direction and branch connections.
10. Verify final equipment locations for roughing-in.
11. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
12. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
13. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 PIPING SPECIALTY INSTALLATION

- A. Embed floor drains in 4-inch-minimum depth of concrete around bottom and sides. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for concrete.
- B. Fasten grates to drains if indicated.
- C. Set floor drains with tops flush with pavement surface.
- D. Install cleanouts and riser extension from sewer pipe to clean out at grade. Use fittings of same material as sewer pipe at branches for cleanouts and riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in pipe.
 1. Set cleanout bodies in earth in cast-in-place concrete block, 18 by 18 by 12 inches deep. Set with tops 1 inch above surrounding grade. Set cleanout plugs in concrete pavement, with tops flush with pavement surface. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for formwork, reinforcement, and concrete requirements.
- E. Install backwater valves in horizontal position. Include riser to clean out at grade.

3.4 JOINT CONSTRUCTION

- A. Chemical-Waste Piping Inside the Building:
 1. Plastic-Piping Fusion Joints: Make PP drainage-piping joints in accordance with ASTM F1290.
 2. Dissimilar-Material Piping Joints: Make joints using adapters compatible with both system materials.

3.5 HANGER AND SUPPORT INSTALLATION

- A. Pipe sizes in this article refer to aboveground single-wall piping and carrier piping of containment piping.
- B. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices. Install the following:
 1. Vertical Piping: MSS Type 8 or MSS Type 42 riser clamps.
 2. Individual, Straight, Horizontal Piping Runs:

- a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.
 3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 4. Base of Vertical Piping: MSS Type 52 spring hangers.
 - C. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for installation of supports.
 - D. Support horizontal piping and tubing within 12 inches of each fitting and coupling.
 - E. Support vertical piping and tubing at base and at each floor.
 - F. Rod diameter may be reduced one size for double-rod hangers, to minimum of 3/8 inch.
 - G. Install vinyl-coated hangers for PP piping with the following maximum horizontal spacing and minimum rod diameters:
 1. NPS 2: 33 inches with 3/8-inch rod.
 2. NPS 2-1/2 and NPS 3: 42 inches with 1/2-inch rod.
 3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
 4. NPS 6: 48 inches with 3/4-inch rod.
 5. NPS 8: 48 inches with 7/8-inch rod.
 - H. Install supports for vertical PP piping every 72 inches.
 - I. Support piping and tubing not listed above in accordance with MSS SP-58.
- 3.6 NEUTRALIZATION SYSTEM INSTALLATION
- A. Install neutralization systems on smooth and level concrete base. Include neutralizing solutions and full initial charge of limestone.
- 3.7 LEAK-DETECTION SYSTEM INSTALLATION
- A. Single-Pipe, Chemical-Waste Sewerage Piping: Install leak-detection system below piping.
 - B. Double-Containment Piping: Install leak-detection system in piping annular space.
 - C. Tanks: Install leak-detection system around bottom of exterior.
 - D. Install panel in location indicated.
- 3.8 CONCRETE PLACEMENT
- A. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for concrete supports.
 - B. Place cast-in-place concrete in accordance with ACI 318/318R.

3.9 PIPING CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Make connections to existing piping, so finished Work complies as nearly as practical with requirements specified for new Work.
- C. Use commercially manufactured wye fittings for sewerage piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting plus 6-inch overlap, with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
- D. Protect existing piping to prevent concrete or debris from entering while making connections. Remove debris or other extraneous material that may accumulate.
- E. Where installing piping adjacent to equipment, allow space for service and maintenance.

3.10 LABELING AND IDENTIFICATION

- A. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for labeling of equipment and piping.
 - 1. Use detectable warning tape over ferrous piping.
 - 2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.11 ADJUSTING

- A. Adjust neutralization-system set points.
- B. Adjust leak-detection-system control and device settings.

3.12 CLEANING

- A. Use procedures prescribed by authorities having jurisdiction or, if not prescribed, use procedures described below:
 - 1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
 - 2. Clean piping by flushing with potable water.

3.13 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service for neutralization systems and leak-detection systems.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Neutralization Systems:
 - a. Verify that neutralization system is installed and connected according to the Contract Documents.

- b. Verify that electrical wiring installation complies with manufacturer's submittal.
- c. Install neutralizing solutions and limestone.
- d. Energize circuits.
- e. Start and run systems through complete sequence of operations.
- f. Adjust operating controls.

3. Leak-Detection Systems:

- a. Verify that electrical wiring installation complies with manufacturer's submittal.
- b. Energize circuits.
- c. Adjust operating controls.

3.14 FIELD QUALITY CONTROL

- A. Inspect interior of sewerage piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place and again at completion of Project.

1. Defects requiring correction include the following:

- a. Alignment: Less than full diameter of inside of pipe is visible between inspection points.
- b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
- c. Crushed, broken, cracked, or otherwise damaged piping.
- d. Hydrostatic Tests for Drainage Piping:
 - 1) Close openings in system and fill with water.
 - 2) Purge air and refill with water.
 - 3) Disconnect water supply.
 - 4) Test and inspect joints for leaks.
- e. Air Tests for Drainage Piping: Comply with UNI-B-6.

- 2. Leaks and loss in test pressure constitute defects that must be repaired.
- 3. Submit separate reports for each test.

- B. Replace leaking sewerage piping using new materials, and repeat testing until leakage is within allowances specified.

- C. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

- D. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

- E. Perform tests and inspections with the assistance of a factory-authorized service representative:

- F. Tests and Inspections:

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect assembled neutralization systems and leak-detection systems and their installation, including piping and electrical connections, and to assist in testing.
 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- G. Chemical-waste piping will be considered defective if it does not pass tests and inspections.
- H. Prepare test and inspection reports.
- 3.15 DEMONSTRATION
- A. Train Owner's maintenance personnel to adjust, operate, and maintain neutralization systems and leak-detection systems.
- 3.16 PIPING SCHEDULE
- A. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used in applications below unless otherwise indicated.
- B. Single-Wall, Chemical-Waste Sewerage Piping: Use the following piping materials for each size range:
1. NPS 1-1/2 to NPS 4: PP drainage pipe and fittings and fusion joints.
 2. NPS 6: PP drainage pipe and fittings and fusion joints.
 3. NPS 8 to NPS 12: PP drainage pipe and fittings and fusion joints.
- C. Underground, Double-Containment, Chemical-Waste Sewerage Piping: Use the following piping materials for each size range:
1. NPS 2 to NPS 12: PP double-containment drainage pipe and fittings.
- D. Aboveground Chemical-Waste Piping: Use the following piping materials for each size range:
1. NPS 1-1/2 to NPS 6: PP drainage piping and fusion joints.
- E. Under Slab-on-Grade, Indoor, Chemical-Waste Piping: Use the following piping materials for each size range:
1. NPS 1-1/2 to NPS 6: PP double-containment drainage piping and manufacturer's standard joints.

END OF SECTION

SECTION 230000

GENERAL REQUIREMENTS FOR HVAC

PART 1 - GENERAL

1.1 FILING OF TRADE BIDS

- A. Trade Bids shall be submitted in accordance with the provisions of the General Laws (Ter. Ed.), Chapter 149, SECTIONS 44A to 44L, inclusive, as set forth under IN- STRUCTIONS TO BIDDERS.
- B. Each Trade Bid filed with the Awarding Authority must be accompanied by a BID BOND, CASH or CERTIFIED CHECK, or a TREASURER'S CHECK or CASHIER'S CHECK issued by a responsible bank or trust company, payable to the Town of Wakefield, the amount stipulated in the INSTRUCTIONS TO BIDDERS. A Trade Bid accompanied by any other form of bid deposit than those specified will be rejected.
- C. Each Trade submitted for the work under the Section, shall be on a form furnished by the Awarding Authority, reference SECTION 44F of Chapter 149 of the General Laws, as amended.
- D. Work to be done under this Section is shown on the following drawings numbered: M0-0-1, M0-0-2, M1-1-0C, M1-1-0D, M1-1-1A, M1-1-1B, M1-1-1C, M1-1-1D, M1-1-2A, M1-1-2B, M1-1-2C, M1-1-2D, M1-1-3A, M1-1-3B, M1-1-3C, M1-1-3D, M1-1-4A, M1-1-4B, M1-1-CB, M1-1-LB, M1-1-MB, M1-2-1A, M1-2-1B, M1-2-1C, M1-2-1D, M1-3-0C, M1-3-0D, M1-3-1A, M1-3-1B, M1-3-1C, M1-3-1D, M1-3-2A, M1-3-2B, M1-3-2C, M1-3-2D, M1-3-3A, M1-3-3B, M1-3-3C, M1-3-3D, M1-3-4A, M1-3-4B, M2-0-1, M2-0-2, M2-0-3, M3-0-1, M3-0-2, M3-0-3, M3-0-4, M3-0-5, M3-0-7, M4-0-1, M4-0-2, M5-0-1, M5-0-2, M5-0-3, and M5-0-4.
- E. The listing of the Contract Drawings above shall not limit responsibility to determine the full extent of work of this Section as required by all Contract Drawings noted on the Contract Drawings-Title Sheet Drawing List, the Project Manual, and Addenda.
- F. Refer and comply with General Instructions prepared by the CM-R.
- G. Work to be done under this SECTION 230000 shall refer to and include the following specification SECTIONS:

23 00 00	GENERAL REQUIREMENTS FOR HVAC
23 00 05	COORDINATION DRAWING REQUIREMENTS FOR HVAC
23 05 13	COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
23 05 16	EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING
23 05 17	SLEEVES AND SLEEVE SEALS FOR HVAC PIPING
23 05 18	ESCUTCHEONS FOR HVAC PIPING
23 05 29	HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT
23 05 48.13	VIBRATION CONTROLS FOR HVAC
23 05 53	IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT
23 05 93	TESTING, ADJUSTING, AND BALANCING FOR HVAC
23 07 13	DUCT INSULATION
23 07 16	HVAC EQUIPMENT INSULATION
23 07 19	HVAC PIPING INSULATION

23 09 10	INSTRUMENTATION AND CONTROL EQUIPMENT
23 09 23	DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC
23 09 93.11	SEQUENCE OF OPERATIONS FOR HVAC DDC
23 23 00	REFRIGERANT PIPING
23 31 13	METAL DUCTS
23 33 00	AIR DUCT ACCESSORIES
23 34 23	HVAC POWER VENTILATORS
23 36 00	AIR TERMINAL UNITS
23 37 13	GRILLES, REGISTERS AND DIFFUSERS
23 72 23.19	PACKAGED INDOOR FIXED PLATE ENERGY RECOVERY UNITS
23 73 43.19	OUTDOOR AND INDOOR, CUSTOM AIR-HANDLING UNITS
23 81 26	SPLIT-SYSTEM AIR-CONDITIONERS
23 81 29	VARIABLE-REFRIGERANT-FLOW HVAC SYSTEMS
23 82 39.13	CABINET UNIT HEATERS
23 82 39.19	WALL AND CEILING UNIT HEATERS

- H. The filed Trade Bidder for Work under this SECTION 230000 shall list in Paragraph E of the FORM FOR TRADE BID the names of each person or corporation whom he proposes to use to perform the following classes of work or part thereof and the bid price, therefore.

CLASS(ES) OF WORK	REFERENCE ARTICLE(S)
TESTING, ADJUSTING AND BALANCING	230593
SHEETMETAL WORK	233113, 233300, 233600, & 233713
INSULATION	230713 & 230719
TEMPERATURE CONTROLS	230910, 230923, & 230993.11

- G. In any case in which the sub-bidder intends to perform with persons of their own staff the class of work listed above, they must nevertheless list their own name therefore under Paragraph E of the FORM FOR SUB-BID.
- H. The HVAC Subcontractor and associated Sub-Subcontractors are specifically directed to review the Fire Protection Narrative Report. All design criteria, coordination issues, testing, and other related items, must be incorporated prior to acceptance of the Fire Protection Systems.

1.2 GENERAL PROVISIONS:

- A. Requirements of General Conditions of the Contract, Supplementary General Conditions and DIVISION 1 (or Part A and DIVISION 1 of Part B) are hereby made a part of this Section as fully as if repeated herein. (Attention is called to DIVISION 1 - GENERAL REQUIREMENTS which may affect the work of this Section.)
- B. Refer to the drawings for further definition of location, extent, and details of the work described herein.
- C. Cooperate and coordinate with all trades in execution of the work described in this Section and so as to provide clearance for equipment maintenance and operation.

- D. Where referred to, standard specifications of Technical Societies, Manufacturers' Associations, and Federal Agencies shall include all amendments current as of the date of issue of these Specifications.
- E. The following sentence is intended for the guidance of the bidders. Wherever it occurs in this Section; when a group of Manufacturers is being referred to, it is the first Manufacturer listed whose equipment has been used in the design of the HVAC system. All material submitted shall be equal in all respects to that used in the design.
- F. The Subcontractor for work of this Section shall become familiar with other Sections of the Specifications to determine the type and extent of work there under which affects the work of this trade, whether or not such work is specifically mentioned in this Section.
- G. All computer equipment hardware and software provided under this Section which has microprocessor based control or monitoring functions which utilize date information shall operate without any error of any nature relating to date data, and without limiting the generality of the foregoing, such hardware, software and systems will not terminate ordinary operations nor produce invalid or incorrect data or information as a result of the input of date data.
 - 1. Any problems arising because of non-compliance with the above shall be corrected by the Contractor without cost to the Owner.

1.3 SCOPE OF WORK:

- A. These specifications and accompanying drawings are intended to cover the furnishing of all labor, material, and equipment and superintendence of the HVAC System. They are also intended to cover performing all miscellaneous operations including excavations and backfilling, cutting, channeling, chasing, and patching necessary for the installation of the HVAC systems, as shown on the drawings, as hereinafter specified, as directed by the Engineer, or as may be required for a complete and fully functional HVAC installation.
- B. It is the intent and purpose of these specifications and accompanying drawings to cover and include each item, all materials, machinery, apparatus, and labor necessary to properly install, equip, adjust, and put into perfect operation the respective portions of the installations specified and to so interconnect the various items or sections of the work as to form a complete and properly operating whole.
- C. Drawings and specifications have been prepared with best knowledge of conditions available at the time of design and are intended to be complementary. What is called for by one shall be as binding as if called for by both. Where conflicts occur between drawings and specifications, or between the HVAC documents and the documents of other disciplines, the situation shall be brought to the attention of the Design Professional before the work in question is installed. In case of conflict between provisions of the Specifications or between the drawings and the specifications, the more stringent requirement shall govern. Where a requirement is applied to a specific product, condition, system, or Specification Section which conflicts with a more general requirement elsewhere, the specific shall supersede the general. If any obscurities or discrepancies exist, they shall be brought to the attention of the Design Professional before bids are submitted. If they are not discovered before bids are submitted, the Design Professional shall be notified and shall render a decision. This decision shall be final.
- D. Any equipment, apparatus, machinery, material, and small items not mentioned in detail, and labor not hereinafter specifically mentioned, which may be found necessary to complete or perfect any portion of installation in a substantial manner, and in compliance with the requirements stated, implied, or intended in these specifications shall be furnished without extra

cost. This shall include all materials, devices, or methods peculiar to the machinery, equipment, apparatus, or systems furnished and installed as part of the HVAC work and shall include major components if so required.

- E. The general arrangement of piping, ductwork and equipment shall be as identified on the contract drawings. Carefully examine all contract drawings and be responsible for the proper fitting of materials and equipment in each location as indicated. Inasmuch as the drawings are generally diagrammatic, due to their small scale, it is not possible to indicate all offsets, fittings, and accessories, as may be required in the final installation. Carefully investigate the site, structural, and finish conditions affecting their work and arrange such work, accordingly, providing such fittings and accessories as may be required to meet such conditions, at no additional cost to the Owner. The right to make any reasonable change in location of apparatus, equipment, outlets or routing of conduit and wiring, up to the time of roughing-in, is reserved by the Design Professional without involving any additional expense to the Owner.
- F. Should a bidder find discrepancies in or omissions from the drawings or specifications they shall notify the Design Professional before submitting their bid proposal. The Design Professional shall then send written instructions, via Addendum, to all known bidders. Oral instructions shall not be binding to either the Design Professional or the Owner.
- G. In the case of discrepancies or conflicts between the Drawings and Specifications, typically the Drawings will take precedence in the case of quantitative issues, while the Specifications will take precedence for qualitative issues; or as specified in other Divisions; however, when the scale and date of the Drawings are the same, or when a discrepancy exists within the Documents and specific written direction cannot be obtained from the Design Professional, Bidders shall include the most stringent requirements. Obtain written clarification from the Engineer prior to installation.
- H. Any such items not brought to the attention of the Design Professional prior to submission of the bids shall be subject to the interpretation of the Design Professional. All such interpretations shall be accepted by the Contractor and shall be incorporated into the construction in a timely manner, at no additional cost to the contract.
- I. These Specifications are arranged in accordance with the MasterFormat 2016, 35 Division format. The Specification is to be read as a whole. Items or work called for on one paragraph or Section, shall be applicable to the entire work, unless specifically indicated otherwise. Specific contract scopes shall be as determined by the General Contractor or Construction Manager.

1.4 LEED/GREEN BUILDINGS CERTIFICATION REQUIREMENTS:

- A. The design of this project involves considerations for Leadership in Energy & Environmental Design (LEED) Certification in accordance with the US Green Building Council.
- B. Refer to other Divisions for project specific Sustainable Design Requirements and information.
- C. All contractors shall become thoroughly familiar with the requirements of the LEED process and specifically the LEED Rating System selected for this project and the individual credits which are being pursued.
- D. Review all specification sections associated with this project for detailed descriptions of installation procedures and documentation requirements.

- E. Provide all documentation required for submission to the US Green Building Council to achieve LEED Certification.

1.5 DEFINITIONS:

- A. The following are definitions of words found in the various Sections of Divisions 23 and on the associated Mechanical drawings:
 - 1. "Concealed" shall indicate hidden from normal sight in furred spaces, shafts, ceiling spaces, walls, and partitions.
 - 2. "Exposed" shall indicate work normally visible, including work in Mechanical or Electrical equipment rooms, tunnels, and similar spaces.
 - 3. "Provide" (and tenses of "provide") – shall indicate "supply and install, complete in all respects, for a complete and fully functional installation."
 - 4. "Install" (and tenses of "install") – shall indicate "secure in position, make all final connections complete, test, verify and certify for a complete and fully functional installation."
 - 5. "Furnish" (and tenses of "furnish") – shall indicate "supply only, complete with all required accessories, mounting hardware, etc., for installation by others, or as spare "attic" stock for the Owner's future use."
 - 6. "Engineer" shall indicate person, firm or Corporation representing the Owner, and identified as such in the Contract Documents. The terms "Engineer" and "Architect" may be used interchangeably throughout the documents.
 - 7. "Authority Having Jurisdiction (AHJ)" shall indicate the organization, office, or individual responsible for enforcing the requirements of the applicable codes or standards in the location where the project is to be constructed.
 - 8. "BAS" shall indicate Building Automation System, and which shall also refer to by equivalent to references to "ATC" – Automatic Temperature Controls, "BMS" – Building Management System or "FMS" – Facility Management System. Any and all of these terms and acronyms may be used interchangeably to refer to the same functional system, specified under Divisions 21 - 25.

1.6 LAWS, REGULATIONS AND CODES:

- A. Perform all work in strict compliance with all laws, regulations, and/or codes applying, including all Federal, State, and local codes and any other authority having jurisdiction. Wherever drawings or specifications conflict with such regulations they shall be made to conform, and approval of the Design Professional obtained on such changes as may be involved.

1.7 QUALITY ASSURANCE:

- A. Comply with the requirements of the following codes and/or standards:
 - 1. ASHRAE
 - 2. ANSI
 - 3. ASME
 - 4. ASTM
 - 5. UL
 - 6. NEMA
 - 7. AMCA
 - 8. NFPA
 - 9. ARI
 - 10. NEC
 - 11. IBC 2015
 - 12. IMC 2015

13. IECC 2018

- B. All packaged equipment shall be independently Third Party labeled as a system for its intended use by a Nationally Recognized Testing Laboratory (NRTL) in accordance with the OSHA Federal Regulations 29CFR1910.303 and .399, as well as NFPA Pamphlet #70 and National Electric Code (NEC), Article 90-7.

1.8 PERMITS, FEES, AND CERTIFICATES OF APPROVAL:

- A. Unless stated otherwise in General Conditions or Division 01, obtain, and pay for all permits, fees, and licenses required, including those of utilities and Agencies. Provide copies to Design Professional in the quantity requested.
- B. "Fees" shall include connection charges construction costs, and other such charges by utility companies or service providers. Ascertain such charges during bidding period and include bid price.

1.9 REQUEST FOR INFORMATION (RFI):

- A. Contractor is responsible for submitting Requests for Information (RFI)s when discrepancies arise, logical discrepancies are found on the contract documents, or clarification is necessary. All RFIs must be clearly written and submitted with a suggested solution. All RFIs regarding changes to the intent indicated on plans must be accompanied by sketches, explanation, site pictures, and all other instruments necessary, to clearly convey the issue at hand and the suggested solution. The RFI process may only be utilized for legitimate purposes. RFIs may not be utilized to submit deviation or substitution requests, nor requesting confirmation of scope for items clearly defined on the contract documents, nor related to clarifications that should be resolved through the Contractor's coordination efforts. RFIs that do not comply will be summarily rejected and any delays caused as a result are the responsibility of the Contractor. In cases where the Contractor does not submit an RFI to clarify an issue and incorrectly proceeds, all work required to resolve such issues to be in compliance with the intent of the contract documents, as determined by the Engineer, shall be the Contractor's responsibility and at no additional cost to the project.
- B. The contractors are required to carefully examine all architectural and structural drawings for the building as well as all of the drawings for electrical trades, IT/AV/Security Trades, mechanical trades, plumbing trades and fire protection trades and be responsible for the proper fitting of all material and equipment into the building as planned and without interference with other piping, ductwork, conduit or equipment. Refer to the coordination drawing requirements. Proper judgment shall be exercised to secure best possible headroom, ceiling heights, door and window clearance, and space conditions throughout; to secure neat arrangement for piping, equipment, and conduit, and to overcome all local difficulties and interferences to best advantage. Approval for any and all changes to plans and specifications which may thus be incurred shall be obtained from the Design Professional before proceeding.

1.10 ALTERNATE PRICES:

- A. Refer to Division 01 Sections for list of Alternate Prices being requested for this project, and if they are to be Add or Deduct alternates.
- B. Where Alternate Prices are solicited, the alternate price shall include all work reasonably associated with the work to be priced as an alternate. Base bid conditions shall provide a complete, and fully functional installation, less the work associated with the alternate price.

1.11 RECORD DRAWINGS:

- A. Throughout the construction keep an accurate, up-to-date record of all deviations of the work between that as shown on the drawings and that which is actually installed.
- B. Obtain a complete set of prints of the Mechanical drawings and note changes thereon. The design professional will provide the CAD files or Revit model for the contractor's use. Make a complete record in a neat and accurate manner, of all changes and revisions to original design which exist in completed work. As-Built markups shall be updated on a daily basis.
- C. Submit As-Built documents in electronic AutoCAD file format. The project design files will be provided to the Contractor by the Design Professional following proper execution of the Document Release and Indemnity Form as provided by the Design Professional. The electronic files returned by the Contractor shall be fully compatible with the native AutoCAD (*.dwg file format). In addition, submit a complete set of drawings in PDF format.
- D. Room names and numbers shall be brought up to date to reflect actual project room signage and designations, which may be different from room indications shown on the contract drawings.
- E. The cost of preparing these record drawings shall be borne by the Contractor. When all revisions showing the work as finally installed are made, the prints and CAD files shall be submitted for review and approval by the Design Professional.
- F. Record drawings shall be delivered to Owner within 30 days of project Substantial Completion.

1.12 OPERATION AND MAINTENANCE MANUALS:

- A. Provide for the Owner's Use one (1) hard copy printed version and one (1) electronic copy in PDF format of a facility Operation and Maintenance Manual.
 - 1. Each hard copy Manual shall be bound in an extra heavy duty three-ring loose-leaf binder with the following title lettered on the front "Record and Information Manual (insert name of project)". No sheets larger than 8-1/2" x 11" shall be used, except sheets that may be neatly folded to 8-1/2" x 11" and used as a pullout.
 - 2. Each electronic format Manual shall be provided as a single .PDF file, fully bookmarked and indexed, containing all Owner's Manual data and project drawings.
- B. Provide the following information in each Manual:
 - 1. Cuts of all equipment with manufacturer's technical specifications. Material shall be manufacturer's brochures, catalog cuts, parts lists, wiring diagrams, etc. Also include approved shop drawings.
 - 2. Operation, Maintenance and Servicing Procedures. Include frequency of inspection, cleaning and adjusting and other attention as may be required in accordance with manufacturer's instructions.
 - 3. Copy of project Warranty.
 - 4. Contact name, telephone number and email address for obtaining replacement parts and service for all equipment.
 - 5. Copy of all individual equipment warranties.
 - 6. Copies of all required Test Reports.
 - 7. USB drive with all Special Systems drawings in both PDF and editable format.
 - 8. Electronic copy of all Owners Instruction and Training Sessions.

- C. Furnish qualified personnel to instruct the Owner's personnel in the maintenance and operation of all equipment and systems. Instructing personnel shall remain on the job continuously during working hours until such instruction is complete, but not less than 16 hours.
- D. A video recording in digital format of the operator training session shall be made during this training period and the digital video submitted to the Owner with the Operation and Maintenance Manuals.

1.13 WARRANTY:

- A. The material and workmanship of all parts of the mechanical installations specified herein and shown on the drawings shall be warranted unconditionally for a period of one (1) year from date of Project Substantial Completion against mechanical and electrical defects arising from faulty materials or workmanship. Either replacement or repairs shall be made promptly on any defective materials or workmanship without charge for materials, equipment, or labor during that period.
- B. Manufacturer's warranties on equipment provided under this contract shall be included in the operating and maintenance manuals.
- C. See specification section regarding restrictions on Early Use of HVAC Equipment.

1.14 CORRECTION OF WORK AFTER FINAL PAYMENT AND WARRANTY:

- A. This article is supplementary to Warranty Provisions of Division 01 and General Conditions.
- B. Final payment shall not relieve the Contractor of responsibility for correction of faulty equipment, materials, and workmanship and, unless otherwise specified, they shall remedy any defects due thereto and pay for damage to other work resulting therefrom, which shall appear within the warranty period specified above.
- C. Include warranties by the respective equipment manufacturers which shall be subject to the terms and time limits defined under these Divisions of Specifications.
- D. Warranties furnished by Sub-Contractor and/or equipment manufacturers shall be counter-signed by the related Prime Contractor for joint and/or individual responsibility for subject item.
- E. Manufacturers' equipment guarantees or warranties extending beyond the warranty period described herein shall be transferred to the Owner along with the Contractor's warranties.

1.15 COMMISSIONING:

- A. Commissioning: Division 23 Contractors and vendors shall be part of a total building and system commissioning effort as conducted by the Commissioning Agent. Each contractor shall provide a technician and tools required to assist and facilitate the commissioning agent, as outlined by the commissioning plan. Where applicable and required, the contractor shall secure and pay for a factory technician to be part of the startup, testing and commissioning team and efforts. Full scope of work and all related responsibilities will be defined in Commissioning documentation.
 - 1. All equipment shall be commissioned, and the operation of that equipment shall be checked by the installing contractor. Specific systems shall be commissioned when more than one contractor is involved in the installation or there is multiple system interface and control involved with that piece of equipment.

2. The contractors shall check and verify all equipment nameplate data against the design parameters, prior to installation.
3. The contractors shall submit a Spare Parts List for all equipment in the Maintenance and Operations Manuals to include, but not limited to the following:
 - a. Part Numbers.
 - b. Part and Equipment Description.
 - c. Quantity of Parts Required.
 - d. Lubrication Requirements.
 - e. Full Warranty Information.
 - f. Complete Operation and Maintenance Manuals.
- B. Provide factory trained technician after successful startup, for on-site support. Allow for ten (10) days on-site for this. These days may not be consecutive.
- C. Provide six (6) additional site visits, after hours, after successful commissioning in the first year. For additional training and troubleshooting.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT:

- A. All installed materials and equipment shall be new and the best of their kind and shall conform to the grade, quality and standards specified herein.
- B. Unless otherwise specifically stated, all materials and equipment offered under these specifications shall be limited to products regularly produced and recommended by the manufacturer for the service intended. This material and equipment shall have capacities and ratings sufficient to amply meet the requirements of the project. The capacities and ratings shall be in accord with engineering data or other comprehensive literature made available to the public by the manufacturer and in effect at the time of opening of bids.
- C. Equipment shall be installed in accordance with manufacturer's instructions for type and quality of each piece of equipment used. These instructions shall be obtained from the manufacturer and shall be considered part of these specifications. Type, capacity, and application of equipment shall be guaranteed suitable to operate satisfactorily. No experimental material or equipment shall be permitted.

2.2 WORK INCLUDED:

- A. Provide all labor, equipment, implements, and materials required to furnish and install all HVAC work (complete and operable) as shown on the drawings and noted herein. The following are major items of work included:
 1. Ductless split system air conditioning units (both cooling only and heat pump).
 2. Heat recovery air-cooled variable refrigerant flow (VRF) systems including fan coil units and condensing units.
 3. Low and medium pressure supply, return, and exhaust air systems, including ductwork, dampers, air terminals, variable volume terminal units (boxes), VAV exhaust terminal units, sound attenuators, grilles, registers and diffusers, flow measuring stations, and static pressure measuring stations.
 4. Electric unit and cabinet unit heaters

5. Variable speed drives (VSD). Provide inverter compatible motors for all equipment connected to VSD's.
6. Automatic Temperature Controls (ATC) and all interlock wiring and monitoring. The ATC Subcontractor shall be active in the review of equipment with integral control packages and shall ultimately be responsible for the proper operation of all controls for the entire project. All DDC control panels and head-end equipment shall be surge protected by the ATC Sub-subcontractor.
7. Indoor and roof mounted energy recovery ventilator, with total energy recovery cores.
8. Custom rooftop and indoor air handling units, with and without total energy recovery wheels.
9. Custom 100% outside air rooftop heat recovery units with energy recovery wheels.
10. Custom 100% outside air rooftop heat recovery units with plate heat exchanger.
11. Heat pump VRF air cooled condensing units to connect to rooftop air handling units.
12. Sound attenuation.
13. Vibration isolation.
14. Thermal insulation.
15. Acoustical lining.
16. Roof vents.
17. Fans.
18. Relocate and install existing Carpentry Shop dust collector from existing school.
19. Balancing and testing of all air and water systems.
20. Motor starters and interlocking devices where integral with equipment and where specifically noted hereinafter.
21. Louvers.
22. Sheetmetal covering and insulation for unused portions of louvers and unused louvers (Blanking Off).
23. The HVAC Trade Contractor shall provide all staging, scaffolding, hoisting and rigging for work of this Section.
24. Start-up of all equipment in this Section. All Start-up Reports shall be included in the Close-out Documents.
25. The HVAC Trade Contractor and the ATC Sub-trade Contractor shall provide cooperation and assistance to the Commissioning Agent (as well as the Testing and Balancing Technician); to perform the work described in SECTION 019113 as well as SECTION 230000 for the systems under this SECTION including but not necessarily limited to the following:
 - a. Fans
 - b. Split system air-cooled water chiller.
 - c. Rooftop units and associated controls.
 - d. Air-source heat pump condensing units connected to air handling units.
 - e. Indoor VRF fan coil units
 - f. Split system air conditioning units.
 - g. System testing and balancing of equipment.
 - h. Variable refrigerant flow systems.
 - i. Building Management System (BMS).
 - j. Piping systems and associated equipment and devices.
 - k. Ductwork systems and associated equipment and devices.
 - l. Cabinet unit heaters and unit heaters.

2.3 EXCAVATION AND BACKFILL:

- A. All excavation and backfill required for HVAC work will be done by Others. Refer to Division 2.
- B. Provide to the appropriate trade all information required to properly perform the excavation work in a timely and coordinated manner.

2.4 CHASES AND OPENINGS:

- A. Provide information to the appropriate trades regarding size and location of all openings and chases as required for the installation of this HVAC Work.
- A. Patching and repair of finishes will be by the General Contractor. Refer to Specification Section 017329.
- B. Provide sleeves for pipes passing through poured concrete decks, footings, walls, etc. Cut all openings for piping passing through precast concrete or existing concrete or masonry. Such holes shall be cut with core drill or similar equipment. They shall not be cut with hammer and chisel, or with any power tool depending on impact for its cutting power.

2.5 CUTTING AND PATCHING:

- A. All cutting and patching for installation of HVAC work will be done by others.
- B. Refer to Specification Section 017329.
- C. Provide all information required for such openings to the appropriate trade in a timely manner.
- D. All patching shall be done in a manner to match appearances and quality of existing surfaces.
- E. Provide sleeves for pipes passing through poured concrete decks, footings, walls, etc. Cut all openings for piping and ductwork passing through precast concrete or existing concrete masonry. Such holes shall be cut with core drill or similar equipment. They shall not be cut with hammer or chisel, or with any power tool depending on impact for its cutting power.

2.6 CONCRETE:

- A. All concrete required for work of the HVAC Contract will be done by others. Refer to Specification Section 033000.
- B. Provide to the appropriate trade all information required to properly complete concrete work.
- C. Provide at the time of pouring concrete, all necessary anchor bolts. Anchor bolts shall be the hook type, or proper size and length to suit the equipment. Anchor bolts shall be set in pipe sleeves of approximately twice the bolt diameter and one half the embedded length of the of the bolt. Assume full responsibility for proper emplacement of bolts.
- D. Drop-in wedge anchor bolts or self-drilling anchors may be used in place of hook bolts. Minimum embedment in concrete of wedge anchor bolts shall be in accordance with manufacturer's instructions. Wedge anchor bolts shall be manufactured by Phillips Drill Co., or USM Corp. Self-drilling anchors shall be manufactured Phillips Drill Co.
- E. After equipment is set in place and bolted down, any space between equipment base and floor slab or foundation shall be completely filled with non-shrink grout equal to Masters Builders Co., Ltd. Embeco 153 grout.

2.7 STARTERS AND PILOT DEVICES (OR MOTOR CONTROLS):

- A. Combination magnetic motor starters shall be full voltage non-reversing with an adjustable instantaneous-trip circuit breaker or fused or unfused safety switch withstand rating 65,000 ampere rms symmetrical minimum

- B. Combination magnetic motor starters shall be full voltage non-reversing with a fused safety switch. Starters and protective devices shall be of sizes recommended by manufacturer for the motor to be controlled, but minimum size shall be NEMA size 1.
- C. Starters, which are not combination shall be similar, but without circuit breaker or switch.
- D. For description of starters, refer to Division 23 and 26 Specifications. This Schedule describes which starters are combination, and if so, what type of device they require. This Schedule also indicates the type of pilot device(s), indicators, auxiliary relays, etc. to be supplied. In the absence of any such instruction, furnish non-combination starter with "hand-off-auto" selector switch, green "run" pilot light, and two (2) auxiliary contacts.
- E. Where starters or other devices are to be mounted outdoors, such as on a cooling tower, enclosures shall be NEMA Type 4. All other enclosures, unless otherwise noted, shall be NEMA Type 1.
- F. All starter control circuits shall be 120V (or 24 VAC if required to interface with BMS/BAS equipment). Voltage shall be derived from starter line voltage via fused control transformer. Control transformers shall have sufficient capacity to properly operate any auxiliary equipment, such as dampers, electro-pneumatic switches, or other devices. Provide transformers larger than manufacturer's standard size, as required by these conditions. Provide sufficient auxiliary contacts to properly interface with ATC equipment, or other devices interlocked with the motor in question.
- G. Manual starters shall be toggle type, in surface or flush enclosure as required, and with pilot light. Provide overload heaters unless the motor to be controlled is thermally protected.
- H. Unless otherwise noted, overload heaters shall be melting-alloy non-automatic-reset type. Overload heaters shall not be selected based on average published motor currents but shall be selected based on the actual nameplate current of motors and service factor as installed.
- I. Push buttons, selector switches, pilot lights and similar pilot devices shall be NEMA 1 or NEMA 4, as noted in D, above. Pilot lights shall be neon or transformer type. Provide manufacturer's standard engraved nameplates which display the control function of the device (or for pilot lights, the action indicated).
- J. Electrical Contractor shall install all individually mounted starters. Division 26 shall provide line and load side power wiring. Coordinate with Division 23 for all BMS/BAS control interface/interlocks. Division 23 shall turn over all starters to Division 26 for installation. Division 26 shall furnish, install, and wire all other (pilot) devices, and provide cell control wiring for starters. See Division 23 "Sequence of Operations" Specification for additional details.
- K. All starters and controls shall be Square D, General Electric, Allen Bradley, Cutler-Hammer or Siemens.

2.8 ELECTRICAL WORK AND MOTORS:

- A. All electrical work shall be done in strict accordance with the requirements of the National Electrical Code and the Electrical Specifications. All electrically operated equipment shall bear an Underwriter's Laboratories label where labeling service is available for that type of equipment.

- B. All motor frames shall be grounded. Electric power, control and grounding connections shall be factory wired to an outlet box or terminal strip enclosure on the apparatus for easy connection by the Electrical Contractor.
- C. All motors shall be designed and constructed in accordance with the latest standards of the IEEE and NEMA and shall meet UL requirements. Motors shall run quietly under all operating conditions.
- D. See Division 23 Specification for additional details.

2.9 WIRING FOR CONTROL SYSTEMS:

- A. This Article applies to wiring used for Automatic Temperature Control (ATC), Building Automation Systems (BAS), Building Management System (BMS), and similar types of control systems associated with work of Division 23.
- B. All wiring for control systems shall comply with Article 725 of the National Electrical Code, (NEC) or with Articles 760, 800, or 820 for control systems integrated into systems covered by those Articles.
 - 1. Particular attention shall be given to the requirements of the NEC for testing and labeling cables for use in plenums, risers, and other air-handling spaces.
- C. All wiring for control systems shall be of a type recommended by the system manufacturer and be installed in accordance with systems manufacturer's instructions.
- D. All Class 2 (24 VAC or less) wiring shall be installed in conduit unless otherwise specified.
 - 1. Class 2 wiring not installed in conduit shall be supported every 5 feet from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements. Exposed wiring shall only be allowed in concealed accessible locations.
 - 2. All wiring installed in Mechanical Equipment Rooms shall be installed in EMT conduit.
- E. Cables must be in raceways when run through inaccessible ceilings, walls, or chases. Cables run on surfaces within 8' of finished floor must be in raceways where exposed to physical damage. Cables in mechanical spaces must be in raceways.
 - 1. Where cables enter or leave raceways, provide insulated bushing or protective grommet.
- F. Cables may be run without raceways above accessible ceilings; in hollow stud partitions; and where properly supported in unfinished spaces without ceilings.
- G. Cables run without raceways in concealed locations or unfinished spaces shall be supported by bridle rings or similar hangers attached to the building structure at maximum 5'-0" centers. Hangers and/or cables shall not be supported from pipes, ducts, or similar equipment. Cables shall not be supported by lying on or across framing members or structural elements.
- H. Where cable is run exposed in finished areas, it shall be supported by bridle rings and beam clamps at maximum 4' intervals. All cables running along a given beam, joist, or truss shall be bundled together and run parallel to each other. Bundle shall be tied together at 2' intervals with T&B "Ty-raps" or equal nylon cable tie. Ty-raps shall be exposed one foot on either side of bridle ring supports. Cables shall be pulled as tight as possible and run as straight as possible.

1. Where cables bend, bends shall be 90 degrees; parallel cables shall have symmetrical turns. Bending radius shall be no smaller than manufacturer's specification for level of cable involved. Individual cables shall be supported with metal straps listed for the purpose. All cables shall be run parallel with or perpendicular to building lines, plumb and true. Cable loops connecting to boxes or fittings shall be as short and neat as possible.
 2. See details on Electrical Drawings for general information regarding cable support. All cables run on steel structure will be painted to match steel; cable supports, ties, etc., must be installed prior to painting.
 3. Cables shall be maintained at a spacing of 6" from 120 V and higher voltage AC conductors, unless installed in a grounded metallic raceway.
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- I. Wiring with or without raceways shall be run continuously between terminal boxes and outlets. All splices shall be made in NEMA 1 boxes with terminal strips or other acceptable connectors and permanent labels to identify each wire and cable, both entering and leaving the box.
 - J. A separation of not less than 6" shall be maintained to heated pipelines.
 - K. Cable run above hung ceilings used for environmental air shall be specifically listed and labeled for the use or shall be installed in a raceway.
 - L. Wiring run without raceways through rated walls, floors and partitions shall be run in sleeves. All such sleeves shall be packed with fire-rated material.
 - M. Wiring for different systems shall be grouped and run separately from other systems and shall be identified as to the system it serves.
 - N. Where equipment to be provided is controlled with line voltage devices (thermostats, speed controllers, timers, etc.), these devices shall be furnished to the electrical contractor for mounting and wiring of same.
 - O. All electrical wiring in connection with the BAS shown on the electrical drawings shall be installed by the Electrical Contractor. Any wiring not shown but required for proper operation of the automatic temperature control system, shall be performed by the Control Contractor and shall be in complete accordance with National Electrical Code, latest edition, and the Electrical Contract Specifications.
- 2.10 FLASHING AND ROOFING WORK:
- A. The Contractor shall perform all cutting, patching, and sealing of existing roofs as required for the installation of all work under this Contract.
 - B. The contractor bears the complete responsibility for maintaining and obtaining the watertight integrity of the affected areas of the roofs both during and after the completion of construction.
 - C. The Contractor shall provide all base flashings, counter flashings, and hot applied roofing materials necessary to properly flash and seal the roofs as required and to prevent any water or moisture leakage whatsoever from occurring as a result of this work.
 - D. Unless noted otherwise, all flashings shall be minimum 24-gauge galvanized steel. Base flashings shall have minimum 4" roof flanges on all sides. Flanges of all base flashings shall be secured and stripped into existing roofing in accordance with the best practices and methods of the roofing trade for a watertight installation.

- E. All joints and seams of all flashings shall be continuously soldered.
- F. After installation, all exposed metal surfaces of base flashings shall be given two (2) applications of roofing coating.
- G. All roofing work shall be performed by first class mechanics experienced in the roofing trade.
- H. Contractor must exercise extreme care so as not to damage existing roofs while working thereon and they shall provide protection planking and plywood as required to achieve this result. Any damage to the existing roofs and their watertight integrity caused as a result of work being performed under this Contract shall be properly repaired by the Contractor to the satisfaction of and at no cost to the Owner.
- I. Refer to drawings for additional flashing details and roofing work required.

2.11 SUBSTITUTIONS:

- A. Equipment may be shown or specified in several ways:
 - 1. Several manufacturers and model numbers listed; or one manufacturer and model number, followed by "equals by (mfr A), (mfr B), (mfr C)," or words of similar respect.
 - a. If one of the manufacturers is listed on the drawings, that manufacturer shall be considered the basis of design. If none is so listed, the first manufacturer named in the Specification shall be considered the basis of design.
 - b. Where manufacturer's or supplier's name, style and catalog numbers are mentioned in the description of material and equipment in the specifications or on the drawings, it is to be understood that they are for the purpose of setting a standard.
 - c. If Contractor elects to furnish equipment other than the basis of design, they shall verify capacities, physical size, code, and manufacturer required access and maintenance clearances, weight, electrical requirements, methods of connection to other parts of the system, and all other relevant data. Contractor shall be responsible for informing the Design Professional in writing of all changes required to other equipment, spaces, structure, or systems in order to install the substituted equipment. They shall furnish all required shop drawings or sketches required for Design Professional to evaluate the required changes and shall be responsible for all costs associated with such changes, including costs of design or engineering, if such are necessary, and costs of other trades.
 - d. Accompany the request for substitution review with a table of comparisons listing pertinent features of both the specified and proposed materials including performance data, weight, material of construction, overall length, width, height dimensions, space required for replacement or maintenance access, motor type, horsepower, voltage, phase service factor, and noise levels. Review of proposed substitution will not be made until receipt of the complete comparison tabulation.
 - 2. Where manufacturer's or supplier's names are listed in conjunction with the manufacturer or supplier that is basis of design, they are given to approve the firm name only. Equipment or material submitted by such firms must meet the detailed technical specifications written for the respective item. Contractor shall be responsible for verifying capacities, physical sizes, weights, electrical requirements, and methods of connection to other parts of the system, etc. Contractor shall furnish all required shop drawings for equipment, and for its connection and installation.

- B. If any substituted items are submitted after contracts have been awarded, and there is any question of equality of such items, samples may be required to be submitted both for the item specified and that to be substituted, or, further proof of equality may be required to the entire satisfaction of the Design Professional. In no case shall additional remuneration be allowed because of the rejection of a substitute.
- C. When the equipment is relocated to a place other than that shown on the drawings, or when equipment other than that specified is used, the Contractor shall pay the extra cost of required revisions such as structural steel, concrete, electrical, piping, etc.

2.12 SHOP DRAWINGS:

- A. Refer to GENERAL CONDITIONS and SUPPLEMENTAL GENERAL CONDITIONS and specifications for shop drawing requirements. The HVAC Subcontractor shall submit the additional information indicated herein.
- B. Furnish shop drawings, catalog cuts, performance data and other required data to the Design Professional for approval for all material and equipment specified hereinafter. Sufficient data shall be submitted to show compliance with the requirements of the plans and specifications. All shop drawings submitted shall be first checked and corrected before submitting for approval. Approval for shop drawings by the Design Professional will not relieve the Contractor from responsibility for errors or omissions therein. All such errors or omissions must be made good by the Contractor irrespective of any approval by the Design Professional.
- C. It is the responsibility of the manufacturer's representative and the installing contractor to thoroughly review all shop drawing equipment submittals and state in writing that the products meet or exceed the design specifications and design intent as indicated on the contract documents, prior to submitting them for review by the engineer.
- D. The General Contractor or Construction Manager shall review and stamp all shop drawings noting their review process has taken place and that the shop drawings are in compliance with the design documents, prior to submitting them for review by the engineer. Any shop drawings found to not be in compliance shall be returned to the contractor stating such, with a copy of the statement (only) forwarded to the engineer.
- E. On submissions beyond the initial one, clearly identify all of the changes made from the initial submittal those requested by the Design Professional. The Design Professional will review only those changes they requested and those identified by the Contractor.
- F. The Engineer will review three submissions (one original submission and up to two revised submissions) on any single component requested for review. If the contractor and/or vendor fail to comply with the drawings, specifications, and/or review comments and additional submissions are required, the cost for review and processing of those submissions will be borne by the contractor.
- G. The design documents are based and coordinated on the scheduled manufacturers. Any substitutions of products or materials (from those approved and listed in the specifications) must be thoroughly coordinated by the submitting contractor. This includes but is not limited to power, space, structural, control and performance requirements.
- H. Shop drawings required shall include, but not necessarily be limited to, the following:
 - 1. Shop drawings, cuts and catalogue information showing appearance, dimensions, performance, weight, etc., of all equipment, appurtenances, etc.

2. Schedules of all materials showing type and manufacturer.
 3. Wiring diagrams and schematics for equipment.
 4. All special equipment and systems.
 5. Any special constructions.
 6. Other shop drawings as may be requested.
 7. Ductwork shop fabrication drawings. See also the requirements in Part Three of this Specification Section.
- I. Digital files of mechanical work will not be provided for the purpose of shop drawing preparation. Digital files of architectural plans, elevations, sections, etc. may be available for background purposes; it is the responsibility of the Contractor to confirm availability prior to bid.
- J. Shop drawings shall be submitted in a timely manner, taking due account of time requirements for processing, correcting, and distributing the shop drawings to all persons or trades requiring the information, as well as time required for manufacture of the equipment. Design Professional will not be responsible for construction delays resulting from late submission of shop drawings, nor for delays caused by the need to correct and resubmit shop drawings which were not correct, which involved substituted equipment, or otherwise required review, correction, and resubmission.
- K. If Contractor elects to proceed to install equipment for which approved Shop Drawings have not been received, they do so at their own risk; Design Professional is not obligated to accept such equipment or work, nor will Design Professional be liable for claimed costs or delays required by correction of such work.
- L. Identify each submittal, including shop drawings, catalog data, test reports, operation and maintenance manuals, and record documents, with the following data:
1. Buyer's name.
 2. Project name.
 3. Project location.
 4. Buyer's purchase order number.
 5. Reference specification order number.
 6. Name of contractor making the submittal.
 7. Revision level of submittal and date of revision.
- M. For equipment, provide the following information on each submittal:
1. Equipment tag number.
 2. Equipment description.
 3. Equipment manufacturer's contact information.
 4. Local equipment representative's contact information.
- N. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristic, finishes for materials, and installation and startup instructions for each type of product indicated.
1. Each control device labeled with setting or adjustable range of control.
- O. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
1. Schematic flow diagrams showing all controlled equipment and control devices.

2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
 3. Details of control panel faces, including controls, instruments, and labeling.
 4. Written description of sequence of operation.
 5. Trunk cable schematic showing programmable control unit locations and trunk data conductors.
 6. Listing of connected data points, including connected control unit and input device.
 7. System graphics indicating monitored systems, data point addresses, and operator notations.
 8. System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
- P. Shop Drawings shall be submitted and shall consist of a complete list of equipment and materials, including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions. Shop drawings shall also contain complete wiring, routing, schematic diagrams, tag number of devices, software descriptions, calculations, and any other details required to demonstrate that the system will function properly. Drawings shall show proposed layout and installation of all equipment and the relationship to other parts of the work.
- Q. Shop Drawings shall be approved before any equipment is installed. Therefore, shop drawings must be submitted in time for review so that all installations can be completed per the project completion schedule. Ten (10) working days shall be allowed for submittals to be reviewed by the Engineer.
- R. All drawings shall be reviewed after the final system checkout and updated or corrected to provide "as-built" drawings to show exact installation. All shop drawings will be acknowledged in writing before installation is started and again after the final checkout of the system. The system will not be considered complete until the "as-built" drawings have received their final approval. The Contractor shall deliver a complete set of "as-built" drawings.
- S. On submissions beyond the initial one, clearly identify changes made from the initial submittal other than those requested by the Design Professional. The Design Professional will review only those changes they requested and those identified by the Contractor.

Shop Drawing Review Comment Definitions

A> No Exception Taken:

The shop drawing or equipment submittal as submitted is approved without exception. No changes or corrections required. The materials, equipment or system submitted can be released for fabrication and construction. No Further Submission Required.

B> Make Corrections Noted:

The shop drawing or equipment submittal as submitted is not completely correct but is approved as noted. Make the corrections noted on the shop drawing or submittal. The materials, equipment or system submitted can be released for fabrication and construction once the corrections have been made. The submittal must be corrected and resubmitted for record unless noted by "E: Resubmit". See "E: Resubmit" definition below.

C> Submit Specified Item:

The shop drawing or equipment submittal as submitted is missing a component of the system that it represents or is not of the approved and specified manufacturers. Submit the missing or

incorrect item. The materials, equipment or system submitted cannot be released for fabrication and construction.

D> No Further Submission Required:

The shop drawing or equipment submittal as submitted is approved as noted. No changes or corrections required. The materials, equipment or system submitted can be released for fabrication and construction. No Further Submission Required.

E> Resubmit:

The shop drawing or equipment submittal as submitted is not approved. The shop drawing or equipment submittal needs significant corrections and does require another submission to verify that the comments and changes have been incorporated. Make the corrections noted on the shop drawing or submittal. The materials, equipment or system submitted cannot be released for fabrication and construction.

F> Rejected:

The shop drawing or equipment submitted is not as specified or a non-approved manufacturer or product and rejected.

G> Resubmit for Record Only:

Make the corrections noted on the shop drawing or submittal. The shop drawing or equipment submittal as submitted is approved with minor exception. Changes or corrections are required. The materials, equipment or system submitted can be released for fabrication and construction.

PART 3 - EXECUTION

3.1 VISIT TO SITE:

- A. Before submitting bid, visit the site of the work and be thoroughly familiarized with the conditions affecting the work. No extra payment will be allowed on account of extra work made necessary by failure to do so.

3.2 WORKMANSHIP:

- A. All work shall be installed in a first class, neat and workmanlike manner by mechanics skilled in the trade involved. All details of the installation shall be mechanically correct. Should the Design Professional direct removal, change, or installation of any equipment or systems not installed in a neat and workmanlike manner, such changes shall be made by the HVAC Contractor at no expense to the Owner.
- B. Equipment shall be installed in strict accordance with manufacturer's instructions for type and capacity of each piece of equipment used. The Contractor shall obtain these instructions from the manufacturer and these instructions shall be considered part of these Specifications.
- C. Drawings are generally indicative of the work to be installed, but do not indicate all bends, fittings, and specialties which may be required, or the exact locations of all piping and ductwork. Contractor shall investigate structure and finish conditions affecting their work and arrange their work; accordingly, furnishing such fittings as may be required to meet such conditions.

Contractor is responsible for exercising proper judgment to arrange their work and materials so as to avoid interference with other trades.

1. Riser diagrams and schematics generally indicate equipment to be used in various systems involved. This information may or may not be duplicated on the plans, but equipment shown on either plans or riser diagrams and schematics shall be provided as if shown on both.
2. All grades, elevations, dimensions, and clearances of equipment shown on drawings are approximate and shall be verified at site.
3. Where work or equipment is referred to in singular terms, such reference shall be deemed to apply to as many items of work or equipment as required to complete entire installation.

- D. Equipment shall be installed according to its installation instructions. Deviations between the specifications and manufacturer's installation instructions shall be brought to the attention of the Engineer for review.

3.3 LINES AND GRADES:

- A. Lay out work and establish heights and grades for work in strict accordance with the intent expressed by the drawings and all the physical conditions at the building and be responsible for the accuracy of same.

3.4 FIELD MEASUREMENTS:

- A. Before ordering any material or doing any work, verify all measurements at the building and site and be responsible for the correctness of same. No extra compensation will be allowed on account of differences between actual dimensions and measurements and those indicated on the drawings. Any difference which may be found shall be submitted to the Design Professional for consideration before proceeding any further with the work.

3.5 DELIVERY OF EQUIPMENT:

- A. Be responsible for delivery of equipment, unload and store in a manner not to interfere with the operation of other trades. Additional expense incurred because of equipment or material delivery delays shall be assumed by the responsible Contractor.

3.6 RESTRICTIONS ON EARLY USE OF HVAC EQUIPMENT:

- A. The HVAC equipment provided under this contract shall not be operated prior to the completion of construction of the building for reasons other than testing and balancing of the systems, unless specifically directed and/or approved by the Owner. This specifically prohibits the use of permanent equipment for the purposes of ventilating, heating, and dehumidifying the building while under construction.
- B. Should a contractor choose to use any component of the permanent HVAC system (i.e. chillers, pumps, air handlers, fan coil units, etc.) for purposes other than stated above, they shall assume full responsibility for replacing or repairing any equipment damaged as a result of the use and pay all costs associated with the action required to make the equipment in "like new" conditions at the end of the project. This includes cleaning of ducts and coils, replacement of motors, extension of warranties, payment of design professional fees required to investigate and enforce this requirement, and the correction of any other detrimental conditions which is determined by the design professionals to be related to the early use of the equipment.

- C. Should the early use of equipment result in manufacturer's warranty being void, the contractor shall assume the cost of furnishing an equivalent warranty to the owner.
- D. Should fan motors be operated during construction, any motor determined by the owner or design professional to be exposed to airborne construction dust, such as generated by drywall sanding, shall be inspected by an independent 3rd party for damage. The cost for the inspection and costs of all required corrective actions shall be borne by the contractor responsible for the operation of the equipment.

3.7 PROTECTION OF WORK:

- A. All work, equipment and materials shall be protected at all times.
- B. All piping openings shall be closed with caps or plugs during installation. All equipment shall be tightly covered and protected against dirt, water, plaster, paint and other foreign material or mechanical injury during entire progress of installation. Make good all damage caused either directly or indirectly by workmen employed to fulfill requirements of the HVAC Work.
- C. Acoustically lined ductwork shall at all times be protected from weather.
- D. Refer to LEED construction IAQ plan.

3.8 REMOVAL OF RUBBISH:

- A. During the course of construction, periodically remove from the premises all rubbish resulting from work of this trade so as to prevent its accumulation. At the completion of the work contemplated under these Specifications remove from the building and site all rubbish and accumulated materials of whatever nature not caused by the other trades and leave work, and equipment free of all foreign matter including plaster, cement, and paint and leave in a clean, orderly, acceptable, and usable condition.

3.9 COORDINATION WITH OTHER TRADES:

- A. Work in conjunction with each of the other trades to facilitate proper and intelligent execution of work with minimum interference.
- B. Carefully examine all architectural and structural drawings for the building and drawings for electrical trade and other mechanical trades and be responsible for the proper fitting of all material and equipment into the building as planned and without interference with other piping, ductwork, conduit, or equipment. Proper judgment shall be exercised to secure best possible headroom, door and window clearance, and space conditions throughout; to secure neat arrangement for piping, equipment, and conduit; and to overcome all local difficulties and interferences to best advantage. Approval for any and all changes to plans and specifications which may thus be incurred shall be obtained from the Design Professional before proceeding.
- C. Contractor shall prepare preliminary sheet-metal shop drawings suitable for use in coordinating their work with the work of other trades. The Mechanical Contractor shall prepare and furnish CAD files of drawings at $3/8" = 1'-0"$ scale illustrating the coordination with all trades. Drawing shall indicate equipment access requirements, piping, ductwork, and conduit in relation to all structural elements of the construction, including floor elevations; steel locations, size, and elevations; partitions locations; door locations and direction of swing; and all other information required to assure coordination of the electrical, sheet-metal and piping trades and fire protection in relation to the Architectural function of the project. Coordination meetings shall be held under the supervision of the Owner's Construction Manager and General Contractor. Each

trade shall have proper representation at all coordination meetings for the purpose of detailing, on a print of the coordinated drawing mentioned above, the exact location and routing of their work. After the conclusion of the coordination at the working meetings, each trade shall sign the coordinated print, copies of which shall be distributed by the GC to all contractors and parties concerned including the Owner. A print of each final coordination CAD drawing with the participants contractor's "signoff" signatures appended shall be submitted to the design professional for record.

- D. If contractor installs work so as to cause interference with work of other trades, they shall make necessary changes in work to correct the condition without extra charge.
- E. Dimensional layout plans of equipment rooms shall be made showing all bases, pads and inertia blocks required for mechanical equipment. Include dimensions of bases, bolt layouts, details, etc.
- F. Contractor shall furnish all necessary templates, patterns, etc. for installing work and for purpose of making adjoining work conform, furnish setting plans and shop details to other trades as required.

3.10 COORDINATION OF CONTROL EQUIPMENT:

- A. The HVAC Contractor shall furnish all starters, push buttons for local or remote control, controllers, pressure switches, aquastats, thermostats, float switches or similar items together with all appurtenances and accessories required to operate the equipment furnished under these specifications and necessary to perform the operating functions as specified, shown on the drawings, or otherwise required.
- B. Refer to Specification Section 230932 and Section 230993.11 for type of controls required. The Electrical Contractor will mount and provide power-wiring for all starters and will furnish and install all other safety switches or other line-disconnecting or protective devices. Where the starter and/or safety switch is an integral part of the equipment assembly, the assembly shall be furnished with the wiring complete between starter, controller and motor and the Electrical Contractor will make power connections only.
- C. All control wiring to automatic-operated switches, pressure switches, aquastats or other devices which actuate the starter or other items associated with the systems shall be furnished, installed, and wired by the HVAC Contractor. The Electrical Contractor will supply 120V electric power to the control panels for these special systems to the extent shown on Electrical Drawings. All other wiring (including additional power circuit if required) shall be the responsibility of the HVAC Contractor.
- D. The HVAC Contractor shall carefully check the current characteristics available to each location before ordering motors.
- E. If procurement requirements necessitate a change in voltage, phase, horsepower or other characteristics of any motor, the HVAC Contractor shall obtain approval of such change from the Design Professional and shall be responsible for necessary arrangements for notifying the Electrical Contractor, and shall pay the costs, if any, required by the change, including Engineering costs.
- F. All electrical equipment furnished and installed under this contract shall be furnished with full complement of control equipment, control wiring, conduit, and all other items necessary for satisfactory operation.

- G. The Electrical Contractor will complete all electrical power connections, through the disconnect and/or thermal cutouts, starter, and motor terminals. They will be responsible for final power connections.
- H. The Electrical Contractor will be responsible for proper rotation of three phase equipment.
- I. All electrical work, equipment and material furnished under this Section shall be furnished and installed in accordance with Division 26 Electrical Specifications.
- J. All panels, relays, terminal boxes, contactors, circuit breakers, safety switches, motor starters and similar items shall be identified by Name, Function and/or Control. Nameplates shall be at least 1" x 3" with characters not less than 1/4". They shall be made of two laminated black plastic sheets bonded with a middle sheet of white plastic and characters engraved in one black sheet to the depth of the white plastic. A typewritten list of Nameplates shall be submitted to the Design Professional for approval before ordering same.

3.11 EXPANSION OF PIPING:

- A. All piping connections shall be made so as to allow for perfect freedom of movement of piping during expansion and contraction, without springing or creating air pockets which will impair the flow of the water through the system. Install expansion loops as shown on the drawing or as required. Expansion loops shall be made with swing joints, bends, or long offsets as necessary. Provide expansion guides.

3.12 ANCHORS AND GUIDES:

- A. Anchors shall be provided where shown and/or required for the proper control of stress in piping due to expansion.

3.13 ACCESS:

- A. All equipment requiring maintenance or adjustment must be accessible. Items located above ceilings shall be located above accessible portions of the ceiling or above access panels provided by this Contractor. Manufactured items with internal components requiring access (whether integral with the enclosure or not) shall be provided with access panels. Access panels shall be provided in ductwork where required for maintenance or adjustment of internal components.

3.14 SPARE FILTERS:

- A. For all equipment provided with filters, this contractor shall provide spare filters to be installed after final acceptance of the systems. It is the responsibility of this contractor to install spare filters.

3.15 FIRE STOPPING:

- A. All penetrations through fire-resistance-rated floor, fire resistance rated, floor/ceiling assemblies and roof construction and through fire-resistance-rated walls and partitions shall be fire stopped.
- B. Penetrations to be fire stopped include both empty openings and those containing cables, pipes, ducts, conduits, and any other items.
- C. Fire rating of sealed penetrations shall meet or exceed the rating of the assembly being penetrated.

- D. Materials shall be installed in accordance with manufacturer's recommendations and their UL listing.
- E. The Furnishing Contractors have included in their bids the services of field representatives to test and start-up the equipment. In cooperation with these field representatives, the Installing Contractor shall check all equipment for proper connections, for alignment, for proper operation, etc.
- F. Furnishing Contractors have included in their bids a one-year warrantee of all equipment. The Installing Contractor shall guarantee on their letterhead that they warrant the installation for the same time period covered by the Furnishing Contractors' Warrantees. They shall further explicitly state therein that they will be responsible for coordinating the correction of any Warrantee items with the Furnishing Contractors and will be responsible for the Furnishing Contractors' timely performance of their Warrantees.

3.16 PREPARATION FOR TESTING AND BALANCING:

- A. Review Contract Documents and submittals to verify that piping, instruments, thermowells, valves, ductwork, dampers, measurement and control devices, and access openings have been provided in correct quantity and at correct locations to permit testing and balancing of air and hydronic systems under various operating conditions.
- B. Provide V-belt drives or variable pitch sheaves for fans as indicated. Provide variable frequency drives as Work of Division 26. Replace variable pitch sheaves or initial fixed pitch sheaves with appropriate fixed pitch sheaves when correct speed (rpm) has been determined by Testing and Balancing Agency. Deliver variable-pitch sheaves and initial fixed pitch sheaves to Owner's Representative. Notify TAB Agency upon completion of sheave replacement.
- C. Inform TAB Agency regarding major deviations from Contract Documents made to systems during construction and furnish one (1) complete set of Record Drawings, showing presence and location of balancing elements, volume dampers, air extractors and instrument ports, prior to start of TAB work.
- D. Provide indicated Work and submit certification that each operation indicated is complete and in accordance with Contract Documents. Accomplish this Work before TAB work can start. Within 30 days of notification by Owner of award of Testing and Balancing Contract, submit schedule to complete following work:
 - 1. Complete physical installation.
 - 2. Pressure test air, and refrigerant piping systems as required.
 - 3. Provide each air system with medium-efficiency disposable start-up filters. Replace filters one (1) time during construction. Replace with new specified filters upon acceptance of each system by Owner's Representative.
 - 4. Test and operate prime movers, including fans, at full design load to verify adequate power, proper rotation, completed controls, operational auxiliaries, and complete overall installation.
 - 5. Balance rotating equipment statically and dynamically.
 - 6. Secure linkages.
 - 7. Verify that automatic control dampers are in proper working order and location, that they are marked and installed with "NORMAL" positions as required. Verify that balancing and shut-off dampers are positioned for full flow. Verify that equipment, terminal devices, and distribution systems are completely and properly connected.

- E. For each item of mechanical equipment, submit typed Data Register in non-yellowing, clear plastic binder, and securely attach it to associated equipment. Show operating temperature, pressure, flow rate, amperage, voltage, phase, frequency (Hz), rpm and brake horsepower {input power (kW)}, as appropriate.
- F. Deliver to TAB Agency, for use until TAB work is complete, flow-indicating devices intended for use with permanently installed primary flow measuring devices. Calibrate permanently installed flow measuring devices and associated display instruments, thermometers, sensors and pressure gauges. Deliver documentation to TAB Agency to verify calibrations.
- G. Submit schedule stating when each system is ready for TAB work to begin. Separate schedule by area, and mechanical system. Submit schedule within 30 days of Contract Award. Update schedule at least two (2) months in advance of scheduled start of TAB work.
- H. Attend coordination meetings between TAB Agency, and Owner's Representative, conducted under guidance of Contractor. First meeting is approximately two (2) weeks before scheduled start of TAB work, as scheduled by Mechanical Contractor and approved by Owner's Representative.
- I. Provide labor, material, tools, and equipment to operate mechanical equipment and systems during TAB work, and for required adjustments, calibrations and repairs of automatic control devices or their components. Provide these services on each working day and without undue delay, as required by TAB Agency. Protect and operate equipment and systems during TAB work.
- J. When requested by TAB Agency, furnish services of personnel to accompany TAB Agency when TAB work is being performed.
- K. Make modifications at no additional cost and to satisfaction of Owner's Representative to rectify discrepancies reported by TAB Agency indicating non-compliance with Contract Documents.

END OF SECTION

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SECTION 230005

COORDINATION DRAWING REQUIREMENTS FOR HVAC

PART 1 – GENERAL

1.1 COORDINATION DRAWINGS

- A. Conform to the requirements of 013100 - PROJECT MANAGEMENT AND COORDINATION. Before work progresses, and in addition to the shop drawings listed herein, submit Coordination Drawings prepared by the HVAC and Sheetmetal Subcontractors at a suitable scale not less than 3/8 inch equals one foot in an AutoCAD 2012 format whichever is preferred by Owner. Provide an electronic file in PDF format of the 3/8 inch sheetmetal HVAC- Coordination Drawings.

1.2 ABOVE CEILING AND NO CEILING OVERHEAD INSTALLATION

- A. The Mechanical Contractor shall furnish minimum 1/4" scale CAD electronic background drawings of the sheet-metal shop drawings, for incorporation of plumbing and mechanical piping services. All ductwork and piping systems shall be thoroughly dimensioned as to location and height above finished floor. Each different system will be drawn in a different color. Upon conclusion of the various systems coordination with the Sheet-Metal Contractor, the composite drawing shall be distributed by the Construction Manager for contractor coordination. All lighting fixture locations will be "ghosted in" by the Sheet-Metal Contractor for coordination of the same. The Sheet-Metal Contractor shall prepare a title box on each drawing which allows space for the signature of the authorized individual from the Sheet-Metal, HVAC Piping, Plumbing, Fire Protection, Electrical, Telecommunications and ATC firms, with the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

NOTE: The composite drawing is in addition to separate shop drawings to be submitted at the conclusion of the coordination process.

- B. At the conclusion of each composite drawing coordination process, the Construction Manager shall be notified by the Mechanical Contractor Project Manager. The Mechanical Contractor Project Manager shall then schedule an on-site coordination meeting for the purpose of signing off on the respective drawing. The Mechanical Contractor shall not be authorized to release any material for fabrication or installation until the composite drawing signature process is executed or until Construction Manager authorizes, in writing, a portion of the work to proceed.
- C. The Mechanical Contractor shall print a weekly status log and maintain a file for the project on this process. Each subcontractor is responsible to submit and coordinate their work with the Construction Manager and Mechanical Contractor.
- D. Provide survey and coordination of underground plumbing for verification of location.
- E. Drawings, if available, may be obtained electronically from the Architect through the Construction Manager.

- F. The Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC Contractors shall receive hard copies of all drawings.
- G. The Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC Contractors shall review all drawings and advise if any additional drawings are needed.
- H. The Mechanical Trade Contractor shall take the lead and develop a drawing list for submissions and a submission schedule coordinated with the construction activities. The drawings shall be developed in a sequential fashion so as to no delay installation of the work or the overall project schedule. The lead Mechanical trade contractor shall include a master key plan so that the area of each drawing can be readily identified as to the location within each building. The Plumbing trade contractor shall lead the underground coordination and the HVAC trade contractor shall lead the balance of the coordination work. The drawing list and schedule shall be forwarded to the Construction Manager for review.
- I. Pursuant to Construction Manager approval of the list and schedule, the Mechanical trade contractor shall provide to all participants the latest plans in a timely fashion in accordance with their schedule.

1.3 SHEET-METAL / PIPING / ATC / ELECTRICAL ACCESS / MAINTENANCE CLEARANCES

- A. As soon as practical, the Mechanical trade contractor shall prepare layout drawings (not less than 3/8" scale) of all ductwork and piping. These drawings shall show all WALL FIRE RATINGS, registers, grilles, diffusers, and similar features, as well as locations of all valves, dampers, damper operators, and other items requiring access for maintenance. It shall also be the responsibility of the Mechanical trade contractor to show on these drawings; beams with bottom elevations, ceiling heights, wall-to-wall dimensions, partitions, columns, windows, doors, electric lighting layouts as shown on the reflected ceiling plans, acoustical ceiling grid, and other major architectural and structural features as shown on the General Construction Drawings. All dimensions should be from centerlines of columns. All required access to equipment for service and/or required for NEC code required clearances shall be shown in a dotted zone.
- B. The Mechanical trade contractor, upon completion of their work, shall email their data back to the Plumbing trade contractor and copy all participants. The Plumbing trade contractor shall download the mechanical data and incorporate, by separate layer, their own routing, as well as other areas requiring access for service and maintenance to determine their relationship and possible interferences with the mechanical, architectural, or structural features to be performed as part of the work.
- C. The Plumbing trade contractor shall then email their data to the Electrical trade contractor and copy all participants. The Electrical trade contractor shall download the drawing and incorporate, by separate layer, their own routings, as well as the depth of all light fixtures, access panels, etc., as required to determine the relationship and possible interferences with plumbing, mechanical, architectural, or structural items to be installed as part of the overall work. The Electrical trade contractor shall be responsible to verify that the electrical lighting layout shown on these drawings is correct and to make corrections and additions of all other light fixtures as required. In areas where no mechanical work occurs, but where other crowded electrical installations are evident, the Electrical trade contractor shall prepare similar drawings.
- D. The Electrical trade contractor shall then email the Fire Protection trade contractor and copy all participants. The Fire Protection trade contractor shall download the drawing and incorporate, by separate layer, their own routings, as well as other areas requiring access for service and maintenance, to determine their relationship and possible interferences with the mechanical, electrical, plumbing, and architectural or structural items to be installed as part of the overall work.

- E. The Mechanical trade contractor shall provide one composite set of reproducible drawings and forward them to the Construction Manager. This composite shall then be reviewed during meetings determined by the Construction Manager, at which all subcontractors including their subcontractors, as required by the Construction Manager, shall be represented to review, and resolve any real or apparent interference or conflicts.
- F. In the preparation of all the final composite drawings, large scale details, as well as cross and longitudinal sections shall be made as required to fully delineate all conditions. Particular attention shall be given to the locations, size and clearance dimensions of equipment items, shafts, and similar features. The final composite drawings shall include the locations of all controls, tie-ins, connections for other subcontractor's work, and pipe and duct insulation as required.
- G. Final composite drawings shall then be signed off by each trade subcontractor indicating their acceptance and approval of the indicated routings and layouts and their relationship with the adjoining or contiguous work of all subcontracts. Thereafter, no unauthorized deviations shall be permitted. If deviations are made without the knowledge and agreement of the Construction Manager and other affected trade contractors, the work in question shall be subject to removal and correction at no additional cost.
- H. In preparing the composite drawings, minor changes in duct, pipe or conduit routings that do not affect the intended function may be made as required to avoid space conflicts, when mutually agreed. Items may not be resized, exposed items relocated, or items run exposed when not intended, without approval. No changes shall be made in any structural members or architectural features which affect the function or aesthetics of the buildings. If conflicts or interferences cannot be satisfactorily resolved, the Engineer shall be notified, and their decision obtained.
- I. After final composite drawings have been accepted and approved, and signed by ALL subcontractors, the Mechanical trade contractor shall provide and distribute to each of the subcontractor and to Construction Manager. Subcontractors requiring further prints for their own distribution will accomplish the same.
- J. The record copies of final composite drawings shall be retained by each subcontractor as a working reference. All shop drawings, prior to their submittal to Construction Manager, shall be compared with the composite drawings and developed accordingly by the subcontractor responsible. Any revisions to the composite drawings, which may become necessary during the process of the work, shall be noted by all subcontractors, and shall be neatly and accurately recorded on the record copies. Each trade contractor shall be responsible for the up-to-date maintenance of their own record copies of the composite drawings and to keep one copy available at the site. The composite drawings and any subsequent changes thereto, shall be utilized by each subcontractor in the development of their as-built drawings. NOTE: The coordination drawings may be used with appropriate changes as as-builts and changes to title block.
- K. Preparation of coordination drawings shall commence as soon as possible after award of the subcontract. The coordination drawings may lack complete data in certain instances pending receipt of equipment drawings, but sufficient space shall be allotted for the items affected. When final information is received, such data shall be promptly inserted on the composite by that trade contractor.
- L. Coordination is the responsibility of all trade contractors. The Construction Manager will call meetings, weekly, or as required, which subcontractors must attend to avoid delay. Failure to attend shall require the trade contractor to field run the work not coordinated. No extra compensation will be paid to any trade contractor for relocating any duct, pipe, conduit, or other material that has been installed without proper coordination. If the installation of any

uncoordinated work or improper installation or coordinated work necessitates additional work by other subcontractors, at the cost of such additional work shall be assigned to the trade contractor responsible as determined by Construction Manager.

- M. All changes in the work of any subcontract shall be shown on the composite drawings.
- N. All work on the coordination composite drawings shall be performed by competent CAD operators, in a clear legible manner. Each trade contractor shall execute a typical drawing activity in no more than three working days. It shall be the responsibility of each subcontractor to supply a sufficient number of CAD operators so as not to delay the coordination process. Construction Manager and Engineer shall be the judge of the acceptability of the drawings.
- O. The composite drawings shall not be used for as-built drawings. (See Paragraph above)
- P. It shall be further understood that each trade contractor's specified submittals shall be transmitted for approval during the coordination period in order that the project encounter no delays.
- Q. The Mechanical trade subcontractor shall pre-coordinate all control equipment locations with the designated ATC trade subcontractor and indicate it on the composite document.

1.4 REQUIREMENTS

- A. All Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC trade contractors shall be required to use AutoCad (CAD) format. Coordination drawings shall be distributed via email or USB drive. ALL EMAILS SHALL BE COPIED TO THE CONSTRUCTION MANAGER.
- B. The Sheet-Metal trade contractor shall prepare a title box on each drawing which allows space for the signature of the authorized individual from the sheet-metal, HVAC, piping, plumbing, sprinkler, electrical and ATC firms with the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."
- C. The Mechanical trade contractor shall not be authorized to release any material for fabrication or installation until the composite drawing signature process is executed or until Construction Manager authorizes, in writing, a portion of the work to proceed.
- D. The Mechanical Contractor shall print a weekly status of all emails sent and received and maintain a hard copy file for use at the coordination "sign-off" meetings. Each subcontractor is required to check emails daily.
- E. Submittals: Once the coordination process has been completed, the coordination drawings shall be submitted to the Engineer for review. A single-color plot, in PDF format, of the drawings shall be submitted for review. The color plot shall delineate between the various disciplines by utilizing different color pens for each system.

PART 2 – PRODUCTS (NOT APPLICABLE)

PART 3 – EXECUTION (NOT APPLICABLE)

END OF SECTION

SECTION 230513

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small, and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. Provide nameplate data including manufacturer, model, service factor, frame size, rpm, HP, voltage, phase, frequency, NEMA enclosure type, full load amperes, Design and Code letters, and insulation class.
 - 2. Provide NEMA nominal and guaranteed minimum efficiencies and power factor at full load, weights and dimensions, UL listing where applicable, and bearing L10 life.
 - 3. Certified sound-power ratings.
- B. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.

1.6 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with NEMA MG 1 unless otherwise indicated.
- B. Motors 1 hp and larger shall be premium efficiency.
- C. Motors on equipment located outdoors shall be totally-enclosed, fan-cooled (TEFC) type. Motors on equipment located indoors shall be open drip-proof (ODP) or TEFC type unless otherwise noted.
- D. Motors and drives shall not produce sound levels exceeding 90 dBA in accordance with Subpart G, Occupational Noise Exposure, of OSHA Standards. Sound measurement data shall be obtained in accordance with IEEE 85. Noise levels exceeding specified limit shall be clearly stated in Submittals.
- E. Two-speed motors shall include separate windings.
- F. 120 volt motors less than 1 hp shall include integral thermal overload protection with manual reset. If an integral overload is not available, format a motor rated toggle switch with thermal overload and provide to the electrical contractor for installation by electrical contractor.
- G. Provide thermostats for hazardous duty and inverter duty motors, where required for warranty, to prevent overheating. Thermostat settings shall be 80 percent of temperature rating.
- H. Motors 10 hp and higher shall include power factor correction to 95 percent, using either factory-installed and wired capacitors, or separately mounted and field-wired capacitors. Capacitors shall be UL-listed, non-PCB with self-healing dielectric film, pressure-sensitive interrupter, discharge resistors, grounding lug, and current-limiting protective fuses. Capacitors shall have 20-year nominal life, two (2) year special warranty, and shall be General Electric-Aerovox, Sprague, ABB, or Versatex. If correction devices are not so furnished, it shall be the responsibility of the Contractor furnishing the equipment to pay all wiring and installation costs.
- I. For VFD motors, provide shaft mounted static discharge dissipation ring with conductive microfibers (Electro Static Technology AEGIS SGR or approved equal) to shunt bearing currents or provide electrically insulated ceramic bearings.
- J. Motor Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. General Electric.
 - 2. MagneTek.
 - 3. Marathon.
 - 4. Reliance.
 - 5. Emerson Motors.
 - 6. Baldor.
 - 7. Toshiba.
- K. Motor Base Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Korfund Dynamics Corp.
 - 2. Mason Industries, Inc.

3. Consolidated Kinetics Corp.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Energy efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
 1. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading. Bearings for 460-volt motors: shielded, regreasable, vacuum degassed steel ball bearings sized for a minimum life (L-10) of 100,000 hours. Bearing housings shall be large enough to hold sufficient lubricant to minimize need for frequent lubrication. Provide extended grease tubes suitable for regreasing bearings in service.
- H. Temperature Rise: Match insulation rating.
- I. Insulation: Class F.
- J. Code Letter Designation:
 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

- C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type or electronically commutating motor (ECM) as specified.

- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

- D. Motors 1/20 HP and Smaller: Shaded-pole type or ECM as specified.

- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

2.6 MOTOR DRIVE AND BASES

- A. Provide motors with Type A, B, C or D matched set V-belt drives or direct drives as indicated.

1. Drives shall be designed for 150 percent of specified motor nameplate horsepower rating.
2. Provide V-belts of endless cord impregnated rubber of trapezoidal cross-section.
3. Provide adjustable screw device for belt tensioning.
4. Drives shall include minimum of two (2) belts.

- B. Provide variable-pitch motor sheaves for fans and other belt-driven equipment under 25 hp. Provide fixed-pitch "initial" motor sheaves for fans and other belt-driven equipment 25 hp and larger. Deliver variable and fixed pitch sheaves to Owner's Representative.

2.7 BELTS AND COUPLING GUARDS

- A. Provide easily removable guards to completely enclose all V-belt drives, pulleys, sheaves and couplings.

- B. Guards shall comply with requirements of Subpart O (Machinery and Machine Guarding) of referenced OSHA Standards.

- C. Tachometers shall be readable with guards in place.
- D. Where grease fittings are enclosed by guards, provide grease fitting extensions to accessible location outside of guard.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install Work in accordance with manufacturer's written instructions.
- B. When not installed with driven equipment on a common base, install and align motors and drives.
- C. Provide field wiring where separately mounted motor capacitors are used.
- D. Provide control wiring from motor thermostats for hazardous duty and inverter duty motors to starter control circuit.

3.2 FIELD QUALITY CONTROL

- A. Visually inspect motors for correct mounting, grounding, power connections and lubrication. Verify that thermostats, RTDs, and other auxiliaries are connected.
- B. Megger test each 460-volt motor 40 hp and above using a 500 V dc test voltage and record the results. Minimum acceptable insulation resistance is 100 megohms. Test duration shall be one (1) minute except motors 200 hp and above shall be tested for ten (10) minutes. Calculate polarization index. Minimum acceptable polarization index is 2.0. Report and correct irregularities immediately.
- C. Furnish calibrated instruments for testing motors.
- D. Perform rotation test for proper shaft direction.
- E. Prepare test and inspection reports.

END OF SECTION

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SECTION 230516

EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Flexible-hose joints.
 - 2. Alignment guides and anchors.
 - 3. Pipe loops and swing connections.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Delegated-Design Submittal: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
 - 2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
 - 3. Alignment Guide Details: Detail field assembly and attachment to building structure.
 - 4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For expansion joints to include in maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.
- B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.2 PACKLESS EXPANSION JOINTS

A. Flexible-Hose Joints:

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Flex-Hose Co., Inc.
 - b. Flexicraft Industries.
 - c. Mason Industries, Inc.
 - d. Metraflex Company (The).
- 2. Description: Manufactured assembly with inlet and outlet fittings and stainless steel flexible hose with braided jacket.
- 3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
- 4. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with solder-joint end connections.
 - a. Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F and 500 psig at 450 deg F ratings.
- 5. Expansion Joints for Steel Piping NPS 2 and Smaller: Carbon-steel fittings with threaded end connections.
 - a. Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F and 515 psig at 600 deg F ratings.

2.3 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Adscro Manufacturing LLC.
 - b. Flex-Hose Co., Inc.
 - c. Flexicraft Industries.
 - d. Flex-Weld, Inc.
 - e. Hyspan Precision Products, Inc.
 - f. Mason Industries, Inc.
 - g. Metraflex Company (The).

2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A 36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Stud: Threaded, zinc-coated carbon steel.
 - b. Expansion Plug: Zinc-coated steel.
 - c. Washer and Nut: Zinc-coated steel.
5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
 - b. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
 - c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION JOINT INSTALLATION

- A. Install expansion loops and fittings in accordance with manufacturer's recommendations.
- B. Install expansion joints of sizes matching sizes of piping in which they are installed.

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

- A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
- B. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.
- C. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.
- D. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

- A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.

- B. Install two guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.
- C. Attach guides to pipe, and secure guides to building structure.
- D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
- E. Anchor Attachments:
 - 1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.
- F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
 - 1. Anchor Attachment to Steel Structural Members: Attach by welding.
 - 2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
- G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION

SECTION 230517

SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Sleeves.
 - 2. Sleeve-seal systems.
 - 3. Sleeve-seal fittings.
 - 4. Grout.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- D. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
- E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
- F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
- G. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

2.2 SLEEVE-SEAL SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.

- B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. HOLDRITE.

- B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.4 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.

2. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
 3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
1. Cut sleeves to length for mounting flush with both surfaces.
 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 1. Exterior Concrete Walls above Grade:
 - a. Piping Smaller Than NPS 4: Galvanized-steel-pipe sleeves.
 - b. Piping NPS 4 and Larger: Galvanized-steel-pipe sleeves.
 2. Exterior Concrete Walls below Grade:

- a. Piping Smaller Than NPS 4: Galvanized-steel-pipe sleeves with sleeve-seal fittings.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 4 and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs-on-Grade:
- a. Piping Smaller Than NPS 4: Galvanized-steel-pipe sleeves with sleeve-seal fittings.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 4 and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
4. Concrete Slabs above Grade:
- a. Piping Smaller Than NPS 4: Galvanized-steel-pipe sleeves.
 - b. Piping NPS 4 and Larger: Galvanized-steel-pipe sleeves.
5. Concrete Slabs above Grade (Mechanical equipment areas or other wet areas):
- a. Piping Smaller Than NPS 4: Galvanized-steel-pipe sleeves with sleeve-seal fittings.
 - b. Piping NPS 4 and Larger: Galvanized-steel-pipe sleeves with sleeve-seal system.
6. Interior Partitions:
- a. Piping Smaller Than NPS 4: Carbon-steel-pipe sleeves.
 - b. Piping NPS 4 and Larger: Carbon-steel-pipe sleeves.

END OF SECTION

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SECTION 230518

ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Escutcheons.
 - 2. Floor plates.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

- A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- C. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.

2.2 FLOOR PLATES

- A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.
- B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. Escutcheons for New Piping:

- a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Insulated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - e. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - f. Bare Piping in Equipment Rooms: One-piece, cast-brass type with polished, chrome-plated finish.
 - C. Install floor plates for piping penetrations of equipment-room floors.
 - D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. New Piping: One-piece, floor-plate type.
- 3.2 FIELD QUALITY CONTROL
- A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION

SECTION 230529

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Fiberglass pipe hangers.
4. Metal framing systems.
5. Fiberglass strut systems.
6. Thermal-hanger shield inserts.
7. Fastener systems.
8. Pipe stands.
9. Equipment supports.

- B. Related Sections:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
3. Section 230548.13 "Vibration Controls for HVAC" for vibration isolation devices.
4. Section 233113 "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

- A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following: include Product Data for components:
 - 1. Trapeze pipe hangers.
 - 2. Metal framing systems.
 - 3. Fiberglass strut systems.
 - 4. Pipe stands.
 - 5. Equipment supports.
- C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Detail fabrication and assembly of hangers.
 - 2. Design Calculations: Calculate requirements for designing hangers, including point loads for each hanger.
 - 3. Diagrams indicating hanger locations and details, type of support, and method of attachment to structure.

1.6 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.7 QUALITY ASSURANCE

- A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
 - 3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
 - 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
- B. Copper Pipe Hangers:
 - 1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.

2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel or stainless steel.

2.2 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit; a part of Atkore International.
 - b. B-line, an Eaton business.
 - c. Flex-Strut Inc.
 - d. Thomas & Betts Corporation; A Member of the ABB Group.
 - e. Unistrut; Part of Atkore International.
 - f. Wesanco, Inc.
2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Standard: MFMA-4.
4. Channels: Continuous slotted steel channel with intumed lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
7. Paint Coating: Epoxy.

B. Non-MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International.
 - b. Empire Industries, Inc.
 - c. ERICO International Corporation.
 - d. Haydon Corporation.
 - e. NIBCO INC.
 - f. PHD Manufacturing, Inc.
 - g. PHS Industries, Inc.
2. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4.
4. Channels: Continuous slotted steel channel with intumed lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
7. Coating: Paint.

2.4 THERMAL-HANGER SHIELD INSERTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Carpenter & Paterson, Inc.
 - 2. Clement Support Services.
 - 3. ERICO International Corporation.
 - 4. National Pipe Hanger Corporation.
 - 5. PHS Industries, Inc.
 - 6. Pipe Shields Inc.
 - 7. Piping Technology & Products, Inc.
 - 8. Rilco Manufacturing Co., Inc.
 - 9. Value Engineered Products, Inc.
- B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.
- C. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.
- D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6 PIPE STANDS

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
- C. High-Type, Multiple-Pipe Stand:
 - 1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
 - 2. Bases: One or more; plastic.
 - 3. Vertical Members: Two or more protective-coated-steel channels.
 - 4. Horizontal Member: Protective-coated-steel channel.

5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

- D. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.7 EQUIPMENT SUPPORTS

- A. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.

2.8 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
 2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-58 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.
- D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- E. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled fiberglass struts.
- F. Thermal-Hanger Shield Installation: Install pipe hanger or shield for insulated piping.
- G. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- H. Pipe Stand Installation:
1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.
- I. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- J. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- K. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- L. Install lateral bracing with pipe hangers and supports to prevent swaying.
- M. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- N. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- O. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- P. Insulated Piping:
1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
 - d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
 - e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 2. Obtain fusion without undercut or overlap.
 3. Remove welding flux immediately.
 4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers and metal framing systems and attachments for general service applications.
- F. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
- G. Use padded hangers for piping that is subject to scratching.
- H. Use thermal-hanger shield inserts for insulated piping and tubing.
- I. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
 - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.
 - 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36, requiring clamp flexibility and up to 4 inches of insulation.
 - 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
 - 5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
 - 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.

7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
 10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
 12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
 17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- J. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.
- K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

- L. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- M. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- N. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.

6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
 - a. Horizontal (MSS Type 54): Mounted horizontally.
 - b. Vertical (MSS Type 55): Mounted vertically.
 - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
- O. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- P. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- Q. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION

SECTION 230553

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Pipe labels.
 - 4. Duct labels.
 - 5. Stencils.
 - 6. Valve tags.
 - 7. Warning tags.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- D. Valve numbering scheme.
- E. Valve Schedules: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Brimar Industries, Inc.
 - c. MSI.
 - d. Seton Identification Products.

2. Material and Thickness: aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
3. Letter Color: Black.
4. Background Color: None.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
7. Fasteners: Stainless-steel self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Brimar Industries, Inc.
 - c. MSI.
 - d. Seton Identification Products.
2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
3. Letter Color: Black.
4. Background Color: White.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. Minimum Letter Size: 1/2 inch. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
8. Fasteners: Stainless-steel self-tapping screws.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Brady Corporation.
 2. Brimar Industries, Inc.
 3. MSI.
 4. Seton Identification Products.

- B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
- C. Letter Color: Black.
- D. Background Color: Yellow.
- E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
- H. Fasteners: Stainless-steel self-tapping screws.
- I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- J. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 PIPE LABELS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Brady Corporation.
 - 2. Brimar Industries, Inc.
 - 3. MSI.
 - 4. Seton Identification Products.
- B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.
- C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.
- D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or, as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: At least 1/2 inch.

2.4 DUCT LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Brady Corporation.
 2. Brimar Industries, Inc.
 3. MSI.
 4. Seton Identification Products.
- B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
- C. Letter Color: Black
- D. Background Color: Blue.
- E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- G. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-quarters the size of principal lettering.
- H. Fasteners: Stainless-steel self-tapping screws.
- I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- J. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings; also include duct size and an arrow indicating flow direction.
1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.

2.5 VALVE TAGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Brady Corporation.
 2. Brimar Industries, Inc.
 3. MSI.
 4. Seton Identification Products.
- B. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 2. Fasteners: Brass wire-link chain or beaded chain.
- C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.6 WARNING TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Brady Corporation.
 2. Brimar Industries, Inc.
 3. MSI.
 4. Seton Identification Products.
- B. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.
 1. Size: 3 by 5-1/4 inches minimum.
 2. Fasteners: Brass grommet and wire.
 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 4. Color: Safety-yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.4 PIPE LABEL INSTALLATION

- A. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 1. Near each valve and control device.
 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.

3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 5. Near major equipment items and other points of origination and termination.
 6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- B. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- C. Pipe Label Color Schedule:
1. Pool Heating Water Piping: White letters on a safety-green background.
 2. Refrigerant Piping: White letters on a safety-black background.

3.5 DUCT LABEL INSTALLATION

- A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
1. Blue: For cold-air supply ducts.
 2. Yellow: For hot-air supply ducts.
 3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
- B. Locate labels near points where ducts enter into and exit from concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.6 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
1. Valve-Tag Size and Shape:
 - a. Refrigerant: 2 inches, round.
 - b. Hot Water: 2 inches, round.
 2. Valve-Tag Colors:
 - a. Toxic and Corrosive Fluids: Black letters on a safety-orange background.
 - b. Flammable Fluids: Black letters on a safety-yellow background.
 - c. Combustible Fluids: White letters on a safety-brown background.
 - d. Potable and Other Water: White letters on a safety-green background.
 - e. Compressed Air: White letters on a safety-blue background.

- f. Defined by User: White letters on a safety-purple background, black letters on a safety-white background, white letters on a safety-gray background, and white letters on a safety-black background.

3.7 WARNING-TAG INSTALLATION

- A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION

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SECTION 230593

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Balancing Air Systems:
 - a. Constant-volume air systems.
 - b. Variable-air-volume systems.
 - 2. Testing, Adjusting, and Balancing Equipment:
 - a. Motors.
 - b. Condensing units.
 - c. Heat-transfer coils.
 - 3. Duct leakage tests.
 - 4. Control system verification.

1.3 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. BAS: Building automation systems.
- C. NEBB: National Environmental Balancing Bureau.
- D. TAB: Testing, adjusting, and balancing.
- E. TABB: Testing, Adjusting, and Balancing Bureau.
- F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- G. TDH: Total dynamic head.

1.4 PREINSTALLATION MEETINGS

- A. TAB Conference: If requested by the Owner, conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.
 - 1. Minimum Agenda Items:

- a. The Contract Documents examination report.
- b. The TAB plan.
- c. Needs for coordination and cooperation of trades and subcontractors.
- d. Proposed procedures for documentation and communication flow.

1.5 ACTION SUBMITTALS

A. LEED Submittals:

1. Air-Balance Report for Prerequisite IEQ 1: Documentation indicating that work complies with ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
2. TAB Report for Prerequisite EA 2: Documentation indicating that work complies with ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.
- C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
- D. System Readiness Checklists: Within 30 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.
- E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- F. Certified TAB reports.
- G. Sample report forms.
- H. Instrument calibration reports, to include the following:
 1. Instrument type and make.
 2. Serial number.
 3. Application.
 4. Dates of use.
 5. Dates of calibration.

1.7 QUALITY ASSURANCE

A. TAB Specialists Qualifications: Certified by AABC, NEBB or TABB.

1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC, NEBB or TABB.
2. TAB Technician: Employee of the TAB specialist and certified by AABC, NEBB or TABB as a TAB technician.

- B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.8 FIELD CONDITIONS

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.
- B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.
- B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine ceiling plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- F. Examine equipment performance data including fan and pump curves.
 - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in

AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design."
Compare results with the design data and installed conditions.

- G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.
- I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
- J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible, and their controls are connected and functioning.
- K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.
- L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.
- M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- N. Examine system pumps to ensure absence of entrained air in the suction piping.
- O. Examine operating safety interlocks and controls on HVAC equipment.
- P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

- A. Prepare a TAB plan that includes the following:
 - 1. Equipment and systems to be tested.
 - 2. Strategies and step-by-step procedures for balancing the systems.
 - 3. Instrumentation to be used.
 - 4. Sample forms with specific identification for all equipment.
- B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
 - 1. Airside:
 - a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
 - b. Duct systems are complete with terminals installed.
 - c. Volume, smoke, and fire dampers are open and functional.
 - d. Clean filters are installed.
 - e. Fans are operating, free of vibration, and rotating in correct direction.
 - f. Variable-frequency controllers' startup is complete, and safeties are verified.
 - g. Automatic temperature-control systems are operational.
 - h. Ceilings are installed.
 - i. Windows and doors are installed.

- j. Suitable access to balancing devices and equipment is provided.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance", NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 - 2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
 - 3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure total airflow.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
 - 2. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.
 - 3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 - 4. Obtain approval from Engineer of Record for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 - 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
 - 1. Measure airflow of submain and branch ducts.
 - 2. Adjust submain and branch duct volume dampers for specified airflow.
 - 3. Re-measure each submain and branch duct after all have been adjusted.
- C. Adjust air inlets and outlets for each space to indicated airflows.
 - 1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
 - 2. Measure inlets and outlets airflow.
 - 3. Adjust each inlet and outlet for specified airflow.
 - 4. Re-measure each inlet and outlet after they have been adjusted.
- D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
 - a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
 - b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
 - c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
 - d. Adjust controls so that terminal is calling for minimum airflow.
 - e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
 - f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
 - g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.
5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
 - c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.

- e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
6. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report any artificial loading of filters at the time static pressures are measured.
7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
 - b. Verify that terminal units are meeting design airflow under system maximum flow.
8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
9. Verify final system conditions as follows:
 - a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
 - b. Re-measure and confirm that total airflow is within design.
 - c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
 - d. Mark final settings.
 - e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
 - f. Verify tracking between supply and return fans.

3.7 PROCEDURES FOR MOTORS

- A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:
 1. Manufacturer's name, model number, and serial number.
 2. Motor horsepower rating.
 3. Motor rpm.
 4. Phase and hertz.
 5. Nameplate and measured voltage, each phase.
 6. Nameplate and measured amperage, each phase.
 7. Starter size and thermal-protection-element rating.
 8. Service factor and frame size.
- B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.8 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.

- C. Record fan and motor operating data.

3.9 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

- B. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.

3.10 DUCT LEAKAGE TESTS

- A. Witness the duct pressure testing performed by Installer.
- B. Verify that proper test methods are used and that leakage rates are within specified tolerances.
- C. Report deficiencies observed.

3.11 CONTROLS VERIFICATION

- A. In conjunction with system balancing, perform the following:

1. Verify temperature control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

- B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.12 TOLERANCES

- A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Pool Heating-Water Flow Rate: Plus or minus 5 percent

- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.13 PROGRESS REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- B. Status Reports: Prepare biweekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.14 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
 - 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 - 2. Include a list of instruments used for procedures, along with proof of calibration.
 - 3. Certify validity and accuracy of field data.
- B. Final Report Contents: In addition to certified field-report data, include the following:
 - 1. Pump curves.
 - 2. Fan curves.
 - 3. Manufacturers' test data.
 - 4. Field test reports prepared by system and equipment installers.
 - 5. Other information relative to equipment performance; do not include Shop Drawings and Product Data.
- C. General Report Data: In addition to form titles and entries, include the following data:
 - 1. Title page.
 - 2. Name and address of the TAB specialist.
 - 3. Project name.
 - 4. Project location.
 - 5. Architect's name and address.
 - 6. Engineer's name and address.
 - 7. Contractor's name and address.
 - 8. Report date.
 - 9. Signature of TAB supervisor who certifies the report.
 - 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 - 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
 2. Water and steam flow rates.
 3. Duct, outlet, and inlet sizes.
 4. Pipe and valve sizes and locations.
 5. Terminal units.
 6. Balancing stations.
 7. Position of balancing devices.
- E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches, and bore.
 - i. Center-to-center dimensions of sheave and amount of adjustments in inches.
 - j. Number, make, and size of belts.
 - k. Number, type, and size of filters.
 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Center-to-center dimensions of sheave and amount of adjustments in inches.
 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.

- d. Discharge static pressure in inches wg.
- e. Filter static-pressure differential in inches wg.
- f. Preheat-coil static-pressure differential in inches wg.
- g. Cooling-coil static-pressure differential in inches wg.
- h. Heating-coil static-pressure differential in inches wg.
- i. Outdoor airflow in cfm.
- j. Return airflow in cfm.
- k. Outdoor-air damper position.
- l. Return-air damper position.
- m. Vortex damper position.

F. Apparatus-Coil Test Reports:

1. Coil Data:

- a. System identification.
- b. Location.
- c. Coil type.
- d. Number of rows.
- e. Fin spacing in fins per inch o.c.
- f. Make and model number.
- g. Face area in sq. ft.
- h. Tube size in NPS.
- i. Tube and fin materials.
- j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

- a. Airflow rate in cfm.
- b. Average face velocity in fpm.
- c. Air pressure drop in inches wg.
- d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
- e. Return-air, wet- and dry-bulb temperatures in deg F.
- f. Entering-air, wet- and dry-bulb temperatures in deg F.
- g. Leaving-air, wet- and dry-bulb temperatures in deg F.
- h. Water flow rate in gpm.
- i. Water pressure differential in feet of head or psig.
- j. Entering-water temperature in deg F.
- k. Leaving-water temperature in deg F.
- l. Refrigerant expansion valve and refrigerant types.
- m. Refrigerant suction pressure in psig.
- n. Refrigerant suction temperature in deg F.
- o. Inlet steam pressure in psig.

G. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:

1. Unit Data:

- a. System identification.
- b. Location.
- c. Coil identification.
- d. Capacity in Btu/h.
- e. Number of stages.
- f. Connected volts, phase, and hertz.

- g. Rated amperage.
 - h. Airflow rate in cfm.
 - i. Face area in sq. ft.
 - j. Minimum face velocity in fpm.
 - 2. Test Data (Indicated and Actual Values):
 - a. Heat output in Btu/h.
 - b. Airflow rate in cfm.
 - c. Air velocity in fpm.
 - d. Entering-air temperature in deg F.
 - e. Leaving-air temperature in deg F.
 - f. Voltage at each connection.
 - g. Amperage for each phase.
- H. Fan Test Reports: For supply, return, and exhaust fans, include the following:
 - 1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches, and bore.
 - h. Center-to-center dimensions of sheave and amount of adjustments in inches.
 - 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
 - g. Number, make, and size of belts.
 - 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Suction static pressure in inches wg.
- I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
 - 1. Report Data:
 - a. System and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F.

- d. Duct static pressure in inches wg.
- e. Duct size in inches.
- f. Duct area in sq. ft.
- g. Indicated airflow rate in cfm.
- h. Indicated velocity in fpm.
- i. Actual airflow rate in cfm.
- j. Actual average velocity in fpm.
- k. Barometric pressure in psig.

J. Air-Terminal-Device Reports:

1. Unit Data:

- a. System and air-handling unit identification.
- b. Location and zone.
- c. Apparatus used for test.
- d. Area served.
- e. Make.
- f. Number from system diagram.
- g. Type and model number.
- h. Size.
- i. Effective area in sq. ft.

2. Test Data (Indicated and Actual Values):

- a. Airflow rate in cfm.
- b. Air velocity in fpm.
- c. Preliminary airflow rate as needed in cfm.
- d. Preliminary velocity as needed in fpm.
- e. Final airflow rate in cfm.
- f. Final velocity in fpm.
- g. Space temperature in deg F.

K. Instrument Calibration Reports:

1. Report Data:

- a. Instrument type and make.
- b. Serial number.
- c. Application.
- d. Dates of use.
- e. Dates of calibration.

3.15 VERIFICATION OF TAB REPORT

- A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of commissioning authority.
- B. Commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

- C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
- D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
- E. If TAB work fails, proceed as follows:
 - 1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
 - 2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
 - 3. If the second verification also fails, [Owner] [design professional] [Architect] may contact AABC Headquarters regarding the AABC National Performance Guaranty.
- F. Prepare test and inspection reports.

3.16 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION

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SECTION 230713

DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes insulating the following duct services:
 - 1. Indoor, concealed supply and outdoor air.
 - 2. Indoor, exposed supply and outdoor air.
 - 3. Indoor, concealed return located in unconditioned space.
 - 4. Indoor, exposed return located in unconditioned space.
 - 5. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
 - 6. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
 - 7. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
 - 8. Indoor, hazardous exhaust systems.
- B. Related Sections:
 - 1. Section 233113 "Metal Ducts" for duct liners.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).
- B. LEED Submittals:
 - 1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
 - 2. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
 - 3. Detail application of field-applied jackets.
 - 4. Detail application at linkages of control devices.

- D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
 - 1. Sheet Form Insulation Materials: 12 inches square.
 - 2. Sheet Jacket Materials: 12 inches square.
 - 3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- C. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA, Inc.
 - b. Armacell LLC.
 - c. K-Flex USA.
- G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Thermal conductivity (k-value) at 75 deg F is 0.27 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CertainTeed Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Manson Insulation Inc.
 - e. Owens Corning.
- H. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA, or Type IB. For duct and plenum applications, provide

insulation with factory-applied FSK jacket. Thermal conductivity (k-value) at 75 deg F is 0.27 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CertainTeed Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Manson Insulation Inc.
 - e. Owens Corning.
- I. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied FSK jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CertainTeed Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Manson Insulation Inc.
 - e. Owens Corning.
- J. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a [1] [2]-hour fire rating by an NRTL acceptable to authorities having jurisdiction.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M.
 - b. CertainTeed Corporation.
 - c. Johns Manville; a Berkshire Hathaway company.
 - d. Nelson Firestop; a brand of Emerson Industrial Automation.
 - e. Thermal Ceramics.
 - f. Unifrax Corporation.
- K. Loaded Vinyl Noise Barrier: Inorganic, incombustible, fiberglass sound absorber with reinforced-foil faced loaded vinyl noise barrier.
 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Sound Seal
 - b. Huschcore
 - c. eNoiseControl

2. Description: 1 lb. pound per square foot reinforced-foil faced loaded vinyl barrier bonded to a 1" thick scrim faced quilted fiberglass absorber.
3. Nominal Thickness: 1 inch.
4. Weight: 1.2 lb psf
5. R Factor: 4.0
6. Flammability Class A per ASTM E-84.
7. Acoustical Performance per ASTM E-90 and E-413:

Minimum Sound Transmission Loss by Octave Band Frequency						
125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	STC
18	18	23	30	39	46	29

2.2 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA, Inc.
 - b. Armacell LLC.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. K-Flex USA.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.
 2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- E. PVC Jacket Adhesive: Compatible with PVC jacket.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Dow Corning Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. P.I.C. Plastics, Inc.
 - d. Speedline Corporation.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Knauf Insulation.
 - d. Vimasco Corporation.
 2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
 3. Service Temperature Range: Minus 20 to plus 180 deg F.
 4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
 5. Color: White.
- C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Knauf Insulation.
 - e. Mon-Eco Industries, Inc.
 - f. Vimasco Corporation.
2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.4 LAGGING ADHESIVES

- A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
 1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Vimasco Corporation.
 3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
 4. Service Temperature Range: 0 to plus 180 deg F.
 5. Color: White.

2.5 SEALANTS

- A. FSK and Metal Jacket Flashing Sealants:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.
 2. Materials shall be compatible with insulation materials, jackets, and substrates.
 3. Fire- and water-resistant, flexible, elastomeric sealant.
 4. Service Temperature Range: Minus 40 to plus 250 deg F.
 5. Color: Aluminum.
 6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
 4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
 5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. with a thread count of 5 strands by 5 strands/sq. in. for covering ducts.
- B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for ducts.

2.8 FIELD-APPLIED CLOTHS

- A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd.

2.9 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division.
 - b. Compac Corporation.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 - e. Venture Tape.
 2. Width: 3 inches.
 3. Thickness: 11.5 mils.
 4. Adhesion: 90 ounces force/inch in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division.
 - b. Compac Corporation.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 - e. Venture Tape.
 2. Width: 3 inches.
 3. Thickness: 6.5 mils.
 4. Adhesion: 90 ounces force/inch in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.
 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Compac Corporation.
 - b. Ideal Tape Co., Inc., an American Biltrite Company.
 - c. Venture Tape.
 2. Width: 2 inches.
 3. Thickness: 6 mils.
 4. Adhesion: 64 ounces force/inch in width.
 5. Elongation: 500 percent.
 6. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division.
 - b. Compac Corporation.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 - e. Venture Tape.
2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.10 SECUREMENTS

A. Bands:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ITW Insulation Systems; Illinois Tool Works, Inc.
 - b. RPR Products, Inc.
 - c. G&B Insulation
2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch-thick, 3/4 inch wide with wing seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch diameter shank, length to suit depth of insulation indicated.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Hardcast, Inc.
 - 4) Midwest Fasteners, Inc.
 - 5) Nelson Stud Welding.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.

- 2) CL WARD & Family Inc.
 - 3) Gemco.
 - 4) Hardcast, Inc.
 - 5) Midwest Fasteners, Inc.
 - 6) Nelson Stud Welding.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch-thick by 2 inches square.
 - c. Spindle: Aluminum, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Gemco.
 - 2) Midwest Fasteners, Inc.
 - 3) AGM Industries, Inc.
 - b. Baseplate: Perforated, nylon sheet, 0.030 inch-thick by 1-1/2 inches in diameter.
 - c. Spindle: Nylon, 0.106-inch-diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
5. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Hardcast, Inc.

- 4) Midwest Fasteners, Inc.
 - b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch-thick by 2 inches square.
 - c. Spindle: Aluminum, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive-backed base with a peel-off protective cover.
6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Hardcast, Inc.
 - 4) Midwest Fasteners, Inc.
 - 5) Nelson Stud Welding.
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Gemco.
 - 2) Midwest Fasteners, Inc.
 - 3) AGM Industries, Inc.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.
- D. Wire: 0.062-inch soft-annealed, galvanized steel.
- 2.11 CORNER ANGLES
- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
 - B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems to be insulated have been tested and are free of defects.

2. Verify that surfaces to be insulated are clean and dry.

- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces, free of voids throughout the length of ducts and fittings.
- B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 1. Install insulation continuously through hangers and around anchor attachments.
 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
 1. Draw jacket tight and smooth.
 2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

- a. For below ambient services, apply vapor-barrier mastic over staples.
- 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
- 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 - 4. Seal jacket to wall flashing with flashing sealant.
- C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
 - 1. Comply with requirements in Section 078413 "Penetration Firestopping" firestopping and fire-resistive joint sealers.
- E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.6 INSTALLATION OF MINERAL-FIBER INSULATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
 5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.

6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.
- B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
 5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.7 FIRE-RATED INSULATION SYSTEM INSTALLATION

- A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
- B. Insulate duct access panels and doors to achieve same fire rating as duct.
- C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."

3.8 FINISHES

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
 - 1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless-steel jackets.

3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 DUCT INSULATION SCHEDULE, GENERAL

- A. Plenums and Ducts Requiring Insulation:
 - 1. Indoor, concealed supply and outdoor air.
 - 2. Indoor, exposed supply and outdoor air.
 - 3. Indoor, concealed return located in unconditioned space.
 - 4. Indoor, exposed return located in unconditioned space.
 - 5. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
 - 6. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
 - 7. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

8. Indoor, exposed and concealed hazardous exhaust.

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

3.11 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Concealed, round, flat-oval, and rectangular, supply, return, and energy recovery unit exhaust duct insulation shall be the following:

1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. Ft. nominal density.

- B. Concealed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 6-lb/cu. ft. nominal density.

- C. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket, thickness as required to achieve 2-hour fire rating.

- D. Concealed, supply and return-air plenum insulation shall be the following:

1. Mineral-Fiber Blanket: 2 inches thick and 1.5-lb/cu. ft. nominal density.

- E. Concealed and exposed, outdoor and exhaust-air plenum insulation shall be the following:

1. Mineral-Fiber Board: 2 inches thick and 6-lb/cu. ft. nominal density.

- F. Exposed, round, flat-oval, and rectangular, supply and return-air duct insulation when duct is located in the space being served shall be the following:

1. None.

- G. Concealed and exposed, dryer exhaust duct insulation when duct is located in the space being served shall be the following:

1. None.

- H. Spray Booth, Power Coating Oven, and Mixing booth Exhaust Duct and Plenum Insulation: Fire-rated blanket, thickness as required to achieve 2-hour fire rating.

3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

- B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Ducts and Plenums, Concealed:

1. None.

D. Ducts and Plenums, Exposed:

1. None.

END OF SECTION

SECTION 230719

HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes insulating the following HVAC piping systems:
 - 1. Condensate drain piping, indoors and outdoors.
 - 2. Refrigerant suction and hot-gas piping, indoors and outdoors.
- B. Related Sections:
 - 1. Section 230713 "Duct Insulation."
 - 2. Section 230716 "HVAC Equipment Insulation."

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
- B. LEED Submittals:
 - 1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
 - 2. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail attachment and covering of heat tracing inside insulation.
 - 3. Detail insulation application at pipe expansion joints for each type of insulation.
 - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 5. Detail removable insulation at piping specialties.
 - 6. Detail application of field-applied jackets.
 - 7. Detail application at linkages of control devices.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.

- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

- C. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.7 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA, Inc.
 - b. Airex Manufacturing.
 - c. Armacell LLC.
 - d. K-Flex USA.
- G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CertainTeed Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Manson Insulation Inc.
 - e. Owens Corning.
- H. Mineral-Fiber, Preformed Pipe Insulation:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. Knauf Insulation.
 - c. Manson Insulation Inc.
 - d. Owens Corning.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - I. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied FSK jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CertainTeed Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Manson Insulation Inc.
 - e. Owens Corning.
- 2.2 INSULATING CEMENTS
- A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
 - B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
 - C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.
- 2.3 ADHESIVES
- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
 - B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA, Inc.
 - b. Armacell LLC.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. K-Flex USA.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
 - C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.
 2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- D. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- E. PVC Jacket Adhesive: Compatible with PVC jacket.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Dow Corning Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. P.I.C. Plastics, Inc.
 - d. Speedline Corporation.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Knauf Insulation.
 - d. Vimasco Corporation.
2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Knauf Insulation.
 - e. Mon-Eco Industries, Inc.
 - f. Vimasco Corporation.
2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.5 SEALANTS

A. Joint Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.
 - e. Pittsburgh Corning Corporation.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.
3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.

5. Service Temperature Range: Minus 100 to plus 300 deg F.
6. Color: White or gray.
7. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
8. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

B. FSK and Metal Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.6 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. Metal Jacket:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ITW Insulation Systems; Illinois Tool Works, Inc.
 - b. RPR Products, Inc.
2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Factory cut and rolled to size.
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
 - d. Moisture Barrier for Outdoor Applications: 2.5-mil-thick polysurlyn.
 - e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.7 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division.
 - b. Compac Corporation.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 - e. Venture Tape.
 2. Width: 3 inches.
 3. Thickness: 11.5 mils.
 4. Adhesion: 90 ounces force/inch in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Avery Dennison Corporation, Specialty Tapes Division.
 - b. Compac Corporation.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 - e. Venture Tape.
 2. Width: 3 inches.
 3. Thickness: 6.5 mils.
 4. Adhesion: 90 ounces force/inch in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.
 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Compac Corporation.
 - b. Ideal Tape Co., Inc., an American Biltrite Company.
 - c. Venture Tape.
 2. Width: 2 inches.
 3. Thickness: 6 mils.
 4. Adhesion: 64 ounces force/inch in width.
 5. Elongation: 500 percent.
 6. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division.
 - b. Compac Corporation.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 - e. Venture Tape.
 2. Width: 2 inches.
 3. Thickness: 3.7 mils.
 4. Adhesion: 100 ounces force/inch in width.
 5. Elongation: 5 percent.
 6. Tensile Strength: 34 lbf/inch in width.

2.8 SECUREMENTS

A. Bands:

1. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch-thick, 1/2 inch wide with wing seal.
2. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 - 1. Verify that systems to be insulated have been tested and are free of defects.
 - 2. Verify that surfaces to be insulated are clean and dry.
 - 3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
 - 1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
 - 2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.

- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above-ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Manholes.

5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
 1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
 1. Pipe: Install insulation continuously through floor penetrations.
 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
 1. Install pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
 4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Pipe Fittings and Elbows:
 1. Install mitered sections of pipe insulation.
 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Insulation Installation on Valves and Pipe Specialties:
 1. Install preformed valve covers manufactured of same material as pipe insulation when available.
 2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 3. Install insulation to flanges as specified for flange insulation application.
 4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 INSTALLATION OF MINERAL-FIBER INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:
 1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
 2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
 3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.

4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.8 FIELD-APPLIED JACKET INSTALLATION

A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints, for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

B. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.9 FINISHES

A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

- a. Finish Coat Material: Interior, flat, latex-emulsion size.
 - B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
 - C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
 - D. Do not field paint aluminum or stainless-steel jackets.
- 3.10 FIELD QUALITY CONTROL
- A. Perform tests and inspections.
 - B. Tests and Inspections:
 - 1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
 - C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.
- 3.11 PIPING INSULATION SCHEDULE, GENERAL
- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
 - B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Drainage piping located in crawl spaces.
 - 2. Underground piping.
 - 3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.
- 3.12 INDOOR PIPING INSULATION SCHEDULE
- A. Condensate and Equipment Drain Water within the building envelope
 - 1. All Pipe Sizes: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
 - B. Refrigerant Liquid, Suction and Hot-Gas Piping and Flexible Tubing:
 - 1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 1-1/2 inch thick.
- 3.13 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE
- A. Refrigerant Suction and Hot-Gas Piping and Flexible Tubing:

1. All Pipe Sizes: Insulation shall be the following:

- a. Flexible Elastomeric: 2 inches thick.

3.14 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed:
 1. None.
- D. Piping, Exposed:
 1. PVC 30 mils thick.

3.15 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed:
 1. None.
- D. Piping, Exposed:
 1. Aluminum, Stucco Embossed with Z-Shaped Locking Seam: 0.032 inch thick.

END OF SECTION

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SECTION 230800

HVAC SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 RELATED SECTIONS

- A. Division 23 – Heating, Ventilating and Air Conditioning
- B. Division 28 - Electronic Safety and Security Systems
- C. Section 019113 – General Commissioning Requirements

1.3 REQUIRMENTS

- A. The Commissioning process requires the participation of Division 23, Mechanical, to ensure that all systems fulfill the functional and pre-functional requirements set forth in these construction documents. The general commissioning requirements and coordination are detailed in Section 019113. Division 23, HVAC, shall fulfill commissioning responsibilities assigned to division 23 in accordance with Section 019113.

PART 2 - PRODUCTS **(NOT USED)**

PART 3 - EXECUTION

3.1 PRE-FUNCTIONAL CHECKLISTS

- A. Pre-functional checklists assist in the process to document that the equipment and systems are installed properly.
- B. The contractor will be provided with construction checklists from the CA for completion. The contractor shall complete the checklists as provide the CA with completed copies in accordance with 019113.
- C. See attached for a sample pre-functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.2 FUNCTIONAL PERFORMANCE TESTING

- A. Intent of functional performance testing is to prove thru functional test procedures proper system operation.

- B. The contractor will be provided with functional performance test procedures to perform while CA witnesses. The contractor shall perform functional tests in accordance with 019113.
- C. See attached for a sample functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.3 PREFUNCTIONAL CHECKLISTS AND FUNCTIONAL PREFORMANCE TESTING

- A. Pre-Functional Checklists and Functional performance testing procedures will be performed on the following system types. (Pre Functional and Functional performance testing requirements are in addition to and do not replace any testing required elsewhere in Division 23 or by applicable codes.) Equipment specifically marked as such below shall be provided with start-up of equipment by factory-authorized service representative.

1. HVAC Systems

- VRF Systems
- Energy Recovery Ventilators with Electric Reheat
- Dedicated Outdoor Rooftop Units with Dx Cooling/Heating and Electric Preheat
- Makeup Air Unit with Dx Cooling/Heating and Electric Reheat
- Rooftop Units with Dx Cooling/Heating and Electric Reheat
- Air Handling Units with Dx Cooling/Heating and Electric Reheat
- Split A/C Units
- Fan terminal Units with Electric Heating

2. SAMPLE CHECKLISTS

- B. See Attached.

END OF SECTION

SAMPLE ONLY

Contractor Checklist and Functional Test Procedures

HOT WATER SYSTEM including Boilers, Pumps and all related components

1. Participants

Discipline	Name	Company
CxA		
Mechanical		
Controls		
TAB		
Plumbing		
Electrical		
Date Returned to CxA		

Check Description

- ☐ The above equipment and systems integral to them are complete and ready for functional testing.
- ☐ All control system functions for this and all interlocking systems are programmed and operable per contract documents, including final setpoints and schedules with debugging, loop tuning and sensor calibrations completed.
- ☐ Test and balance completed and approved for the hydronic systems and terminal units connected
- ☐ All A/E punchlist items for this equipment corrected.
- ☐ Safeties and operating ranges reviewed.
- ☐ Schedules and reviewed
 - This checklist does not take the place of the manufacturer's recommended checkout and startup procedures.
 - Items that do not apply shall be noted with the reasons on this form (N/A = not applicable, BO = by others).
 - Contractors assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off.

3. Installation Checks

	Boilers and System		
Check	B-1	B-2	COMMENTS
General Installation			
Permanent labels affixed	<input type="checkbox"/>	<input type="checkbox"/>	
Casing condition good: no evidence of damage	<input type="checkbox"/>	<input type="checkbox"/>	
Concrete pad provided (4-6") to ensure proper condensate drainage	<input type="checkbox"/>	<input type="checkbox"/>	
Thermal insulation properly installed	<input type="checkbox"/>	<input type="checkbox"/>	
Instrumentation installed according to specification (thermometers, pressure gages, flow meters, etc.)	<input type="checkbox"/>	<input type="checkbox"/>	
Clean up of equipment completed per contract documents	<input type="checkbox"/>	<input type="checkbox"/>	
Installation of combustion air fan and associated motorized damper	<input type="checkbox"/>	<input type="checkbox"/>	
Relief valve on boiler properly piped	<input type="checkbox"/>	<input type="checkbox"/>	
Boiler drain valves	<input type="checkbox"/>	<input type="checkbox"/>	
ASME Pressure relief valve	<input type="checkbox"/>	<input type="checkbox"/>	
Sensors calibrated	<input type="checkbox"/>	<input type="checkbox"/>	
HWR Manual Isolation Valve	<input type="checkbox"/>	<input type="checkbox"/>	
HWR Main Temperature Sensor-ATC	<input type="checkbox"/>	<input type="checkbox"/>	
HWS Main Temperature Sensor-ATC	<input type="checkbox"/>	<input type="checkbox"/>	
HWS Main isolation valve upstream of Air Separator	<input type="checkbox"/>	<input type="checkbox"/>	
HWR Isolation Valves to Boilers	<input type="checkbox"/>	<input type="checkbox"/>	
Emergency Boiler Switch at Door	<input type="checkbox"/>	<input type="checkbox"/>	
Exhaust vent pipe completely sealed to prevent leakage of combustion products	<input type="checkbox"/>	<input type="checkbox"/>	
Manual Gas shutoff valve in place in case of overheating or gas supply failure. Location apparent	<input type="checkbox"/>	<input type="checkbox"/>	
Minimum clearance has been met as indicated Sides: 24 Inches Front: 24 Inches Rear: 30 Inches Top: 18 Inches	<input type="checkbox"/>	<input type="checkbox"/>	
Floor drain in place or condensate pump used to remove condensate	<input type="checkbox"/>	<input type="checkbox"/>	
Condensate drain trap associated fitting and drain line are removable for maintenance	<input type="checkbox"/>	<input type="checkbox"/>	
If using a sealed combustion air configuration, each unit must have a min of 8 inch diameter connection at unit.	<input type="checkbox"/>	<input type="checkbox"/>	
Valves and Piping and associated equipment			
Expansion tank installed	<input type="checkbox"/>		
Expansion Tank Auto Air vent	<input type="checkbox"/>		
Expansion Tank drain valve installed	<input type="checkbox"/>		
Expansion Tank Isolation Valve	<input type="checkbox"/>		
Air Separator in place between boilers and pumps	<input type="checkbox"/>		
Air Separator high capacity air vent installed	<input type="checkbox"/>		
Air Separator Drain in place	<input type="checkbox"/>		
Air Separator between boiler hot water supply and pump suction	<input type="checkbox"/>		
Piping arrangement installed per the contract documents	<input type="checkbox"/>		

Check	Boilers and System		COMMENTS
	B-1	B-2	
Installation of chemical pot feeder and support devices	<input type="checkbox"/>		
Pipe fittings complete and pipes properly supported by floor, ceiling or walls and NOT by unit	<input type="checkbox"/>		
Pipes properly labeled	<input type="checkbox"/>		
Pipes properly insulated	<input type="checkbox"/>		
Valves properly labeled	<input type="checkbox"/>		
Valves installed in proper direction	<input type="checkbox"/>		
Piping system properly flushed	<input type="checkbox"/>		
No leaking apparent around fittings	<input type="checkbox"/>		
PRV - Automatic Fill and Check Valve installed on Makeup Water	<input type="checkbox"/>		
Pressure gauge installed after PRV on Cold Water Fill	<input type="checkbox"/>		
Glycol makeup Units fill valve in place	<input type="checkbox"/>		
Glycol makeup manually adjustable pressure switch	<input type="checkbox"/>		
Glycol makeup Control Panel in place	<input type="checkbox"/>		
Glycol makeup low water pilot light in place	<input type="checkbox"/>		
Glycol makeup manual shutoff on CW makeup	<input type="checkbox"/>		
Glycol makeup High level switch dry contacts in place to alarm at BMS	<input type="checkbox"/>		
Glycol makeup Low level switch dry contacts in place to alarm at BMS	<input type="checkbox"/>		
Glycol Makeup pump and piping (w/ instrumentation) according to detail.	<input type="checkbox"/>		
Chemical pot feeder installed as per detail	<input type="checkbox"/>		
Electrical and Controls			
Power disconnects in place and labeled	<input type="checkbox"/>	<input type="checkbox"/>	
Electrical conduit and hardware does not interfere with removal of any unit covers or inhibit maintenance/service	<input type="checkbox"/>	<input type="checkbox"/>	
No other devices share the same electrical circuit as the boilers	<input type="checkbox"/>	<input type="checkbox"/>	
All electric connections tight	<input type="checkbox"/>	<input type="checkbox"/>	
Safeties in place and operable	<input type="checkbox"/>	<input type="checkbox"/>	
Low water cut-off switch	<input type="checkbox"/>	<input type="checkbox"/>	

	Pumps		
Check	HWP-1	HWP-2	COMMENTS
General Installation			
Permanent labels affixed	<input type="checkbox"/>	<input type="checkbox"/>	
Casing condition good: No Damage	<input type="checkbox"/>	<input type="checkbox"/>	
Vibration Isolation in place	<input type="checkbox"/>	<input type="checkbox"/>	
Piping and Valves			
Common pressure gauge installed	<input type="checkbox"/>	<input type="checkbox"/>	
Piping insulated	<input type="checkbox"/>	<input type="checkbox"/>	
Piping labeled	<input type="checkbox"/>	<input type="checkbox"/>	
Associated valve appropriately labeled with valve tags	<input type="checkbox"/>	<input type="checkbox"/>	
Triple Duty Valve installed	<input type="checkbox"/>	<input type="checkbox"/>	

Check	Pumps		COMMENTS
	HWP-1	HWP-2	
Isolation Valves installed as per documents	<input type="checkbox"/>	<input type="checkbox"/>	
Drain installed with	<input type="checkbox"/>	<input type="checkbox"/>	
Manual air vent installed	<input type="checkbox"/>	<input type="checkbox"/>	
Electrical and Controls			
VCF installed as per contract documents	<input type="checkbox"/>	<input type="checkbox"/>	
Disconnect in place and labeled	<input type="checkbox"/>	<input type="checkbox"/>	
All control devices installed properly	<input type="checkbox"/>	<input type="checkbox"/>	

4. Performance Tests

Test	Compliance/Non-Compliance	Compliance/Non-Compliance	Comments
	B-1	B-2	
Performance Tests			
Calibration of BAS HWS and HWR		<input type="checkbox"/>	
Calibration of outdoor air sensor		<input type="checkbox"/>	
Capability of the temperature control system to stop/start boiler. Verify the motorized damper on combustion air fans opens prior to the start of the boiler.	<input type="checkbox"/>	<input type="checkbox"/>	
Hot water reset schedule capability at BAS OA 20°F = 150°F OA 55°F = 110°F		<input type="checkbox"/>	
Record sequencing and/or operation of boilers when system is activated such that both boilers operate to maintain setpoint.	<input type="checkbox"/>	<input type="checkbox"/>	
Boiler safeties, staging and modulation shall be controlled thru the boiler control panel provided by the MFG		<input type="checkbox"/>	
Boilers operate in parallel		<input type="checkbox"/>	
Boilers are off when outdoor air is above 65 deg. F. adj.		<input type="checkbox"/>	
Boiler start time delay to prevent short cycling.		<input type="checkbox"/>	
Operation of hi water temp safeties for both boilers.	<input type="checkbox"/>	<input type="checkbox"/>	
Operation of low water cut off boiler Safeties for both boilers	<input type="checkbox"/>	<input type="checkbox"/>	
Boiler alarm bells in place and functional??	<input type="checkbox"/>	<input type="checkbox"/>	
Installation of a low temperature water alarm signal at the BAS. Record setpoint.	<input type="checkbox"/>	<input type="checkbox"/>	
Boiler/Burner Emergency Shutdown Switches at each entry door hardwired to boiler and burner controls		<input type="checkbox"/>	
Burner status in place	<input type="checkbox"/>	<input type="checkbox"/>	
Operating status of pumps	<input type="checkbox"/>	<input type="checkbox"/>	
Startup report performed only by manufacturer trained startup and service personnel has been provided and includes the performance of the combustion air calibration, proper set up of controls and limits, proper setup of modes of operation, and testing of all safety devices	<input type="checkbox"/>	<input type="checkbox"/>	

Graphic (Operator Station) Display	Compliance or Non Compliance	Comment
Equipment identification	<input type="checkbox"/>	
Boiler Enable/Disable	<input type="checkbox"/>	
Boiler(s) alarm status	<input type="checkbox"/>	
Supply water temperature sensor	<input type="checkbox"/>	
Supply water temperature setpoint	<input type="checkbox"/>	
Return water temperature sensor	<input type="checkbox"/>	
Pump Start/Stop	<input type="checkbox"/>	
Pump(s) Status	<input type="checkbox"/>	
Pump(s) VFD status	<input type="checkbox"/>	
Pump(s) VFD speed	<input type="checkbox"/>	
Pump(s) VFD alarm	<input type="checkbox"/>	
Differential pressure setpoint	<input type="checkbox"/>	
Differential pressure status	<input type="checkbox"/>	
Bypass valve command	<input type="checkbox"/>	
Outside air temperature indication	<input type="checkbox"/>	
Glycol Unit Identification	<input type="checkbox"/>	
Glycol Pump Status	<input type="checkbox"/>	
Glycol high level alarm (thru dry contacts)	<input type="checkbox"/>	
Glycol low level alarm (thru dry contacts)	<input type="checkbox"/>	
Glycol percentage alarm	<input type="checkbox"/>	

5. Functional Testing Record

Test #	Test Name	Test Procedure (including special conditions)	Expected Response	Pass Y/N	
				Heating System	
				B-1	B-2
1	Heating System Enable	Override OA sensor and set below 60 deg F	Lead Boiler, associated Lead Primary Pump and Lead Secondary Hot Water Pump shall be energized on along with the oil transfer pumps		
2	Heating System Disable	Override OA sensor and set above 60 deg F	All boilers shall be disabled along with their associated primary pumps and the lead secondary pump.		
3	Operating control	Change parameters of the reset schedule to simulate a change in need for hot water supply temperature to the loop. Parameter setting shall be as follows but fully adjustable. OA Supply Temp 20°F 150°F 55°F 110°F	Ensure the BMS recalculates the system hot water setpoint. Boiler shall operate and burner shall control via internal controls until building hot water supply temperature in the common header reaches the setpoint (based on a reset schedule inversely proportional to outside air temperature		
4	Low Water Level Fault	Simulate a low water condition by tripping the low water cutout switch	Burner shuts down and alarm sent to BMS		

Test #	Test Name	Test Procedure (including special conditions)	Expected Response	Pass Y/N	
				Heating System	
				B-1	B-2
5	High Water Temperature Fault	Adjust the automatic over-temperature switch on front of unit. Lower the temp limit switch setting to match the displayed outlet temp	The unit should shut down. The fault indicator should start flashing and a high water temp switch open fault message should be displayed. Be sure to return the switch to its original setting to reset.		
6	Flame Fault	Set the On/Off switch to OFF. Place the unit in the Manual Mode and set the firing rate between 14% and 30%. Close the manual gas shutoff valve	The unit shall shut down		
7	Boiler and Burner Emergency Shutdown Control	Interrupt each burner safety circuit to turn off the boiler/burner by manually operated remote shutdown switch located at each boiler room door	Burner/boiler shall shutdown as it the switch is hardwired to the boiler/burner controls		
8	Autofill Make-up Unit	NOTE: Unit is controlled through factory supplied controls. Ensure that the following is happening	When the system pressure drops below setpoint of the pressure switch, the pump shall start and add fluid from the tank into the system. When the pressure setpoint is satisfied, the pump shall stop. A low condition (low level switch) will stop or not allow the pump to start.		

Test #	Test Name	Test Procedure (including special conditions)	Expected Response	Pass Y/N	
				HWP-1	HWP-2
11	Secondary Pumps Enable	Enable the heating system	Lead secondary pump shall operate continuously when activated.		
12	Secondary Pump Disable	Disable the heating system	The secondary pumps shall not run when the heating system is not energized.		
13	Secondary Pump Failure	Manually fail the lead secondary pump at VFD	An alarm shall be sent to the BMS and the lag pump shall be enabled and shall run continuously		
14	Secondary Pump Lead/Lag Swap	Set up trends on Secondary Pump Status.	Pumps shall alternate to equalize runtime. Selection of the lead and lag pump shall be evaluated on a weekly basis. The pump with the elast amount of run time is lead. The remaining is the lag.		
		Manually swap the pumps via BMS controls	Ensure that the lead secondary pump swaps		
15	Secondary Pump Speed	Change the differential pressure (dp) setpoint	The pumps are controlled by (2) system dp sensors thru the associated VFD's. The controller will monitor both sensors and will control to maintain the setpoint using the sensor which is farthest from setpoint. The VFD shall ramp up and down to maintain the differential pressure setpoint per sensor(s).		

				Pass Y/N	
Test #	Test Name	Test Procedure (including special conditions)	Expected Response	HWP-1	HWP-2
	Bypass Valve Operation	Simulate a situation where the frequency of the operating pump VFD drops to 15 HZ.	Should the frequency of the operat- ing pump drop to 15 HZ, the bypas valve shall open to maintain system pressure		

SECTION 230910

INSTRUMENTATION AND CONTROL EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section specifies minimum requirements for all instrumentation and control equipment and shall be fully coordinated and integrated with Division 23 and 26 sections. Provide instrumentation and control equipment, submit documentation including equipment catalogs, calibrate, test, place in service, and supply spare parts and associated labor for first year of operation for instrumentation and controls required for mechanical and electrical equipment and systems provided in accordance with Contract Documents.
- B. Related Requirements:
 - 1. Section 230923 "Direct Digital Control System for HVAC" for equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
 - 2. Section 230993 "Sequence of Operations for HVAC Controls".

1.3 DEFINITIONS

- A. BAS: Building Automation System.
- B. BMS: Building Monitoring System.
- C. Cv: Design valve coefficient.
- D. DDC: Direct-digital control.
- E. Ethernet: Local area network based on IEEE 802.3.1 standards.
- F. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.
- G. HART: Highway addressable remote transducer protocol is the global standard for sending and receiving digital information across analog wires between smart devices and control or monitoring systems through bi-directional communication that provides data access between intelligent field instruments and host systems. A host can be any software application from technician's hand-held device or laptop to a plant's process control, asset management, safety, or other system using any control platform.
- H. I/O: Input/output
- I. NBR: Nitrile butadiene rubber.

- J. PTFE: Polytetrafluoroethylene
- K. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.
- L. RS-232: A TIA standard for asynchronous serial data communications between terminal devices.
- M. RS-485: A TIA standard for multipoint communications using two twisted pairs.
- N. RTD: Resistance temperature detector.
- O. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product, including the following:
 - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 - 3. Product description with complete technical data, performance curves, and product specification sheets.
 - 4. Installation, operation, and maintenance instructions, including factors affecting performance.
- B. LEED Submittals
 - 1. Product data for energy instruments for use in showing compliances with instruments and verification credit.
 - 2. Product data for air flow instruments for use in showing compliances with requirements in ASHRAE 62.1
- C. Shop Drawings:
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
 - 4. Include diagrams for air and process signal tubing.
 - 5. Number-coded identification system for unique identification of wiring, cable, and tubing ends.
- D. Delegated-Design Submittal:
 - 1. Schedule and design calculations for control valves and actuators, including the following:
 - a. Flow at project design and minimum flow conditions.

- CV valves for each valve including range from 20 degrees to 70 degrees.
- b. Damper face velocity at project design and minimum airflow condition.
- c. Pressure drop across each valve and damper and flow sensor at project design and minimum flow condition.
- d. Maximum system pressure differential drop (pump close-off pressure) across valve at project minimum flow condition.
- e. Design and minimum control valve coefficient with corresponding valve position.
- f. Maximum close-off pressure.
- g. Leakage flow at maximum system pressure differential.
- h. Torque required at worst case condition for sizing actuator.
- i. Actuator selection indicating torque provided.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Control valve and damper installation location shown in relationship to room, duct, pipe, and equipment.
 - 2. Size and location of wall access panels for control valves and dampers installed behind walls.
 - 3. Size and location of ceiling access panels for control valves and dampers installed above inaccessible ceilings.
 - 4. Wall-mounted instruments located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.
- B. Product Certificates: For each product indicated requiring a certificate.
- C. Product Test Reports: For each product indicated, for tests performed by a qualified testing agency.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For control valves to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials and parts that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Provide parts, as indicated by manufacturer's recommended parts list, for product operation during one-year period following warranty period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.
- C. Delegated Design: Engage a qualified professional, to size products where indicated as delegated design.
- D. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.
- E. Control Valves:
 - 1. Determine control valve sizes and flow coefficients by ISA 75.01.01.
 - 2. Control valve characteristics and rangeability shall comply with ISA 75.11.01.
 - 3. Control valve shutoff classifications shall be FCI 70-2, Class IV or better unless otherwise indicated.
 - 4. Valve pattern, three-way or straight through, shall be as indicated on Drawings.
 - 5. Modulating straight-through pattern control valves shall have equal percentage flow-throttling characteristics unless otherwise indicated.
 - 6. Modulating three-way pattern water valves shall have linear flow-throttling characteristics. The total flow through the valve shall remain constant regardless of the valve's position.
 - 7. Globe-type control valves shall pass the design flow required with not more than 95 percent of stem lift unless otherwise indicated.
 - 8. Rotary-type control valves, such as ball and butterfly valves, shall have Cv falling between 65 and 75 degrees of valve full open position and minimum valve Cv between 15 and 25 percent of open position.
 - 9. Selection shall consider viscosity, flashing, and cavitation corrections.
 - 10. Valves shall have stable operation throughout full range of operation, from design to minimum Cv.
 - 11. Two-position control valves shall be line size unless otherwise indicated.
- F. Control Dampers:
 - 1. Dampers shall have stable operation throughout full range of operation, from design to minimum airflow over varying pressures and temperatures encountered.
 - 2. Control dampers shall be full size of duct or equipment connection unless otherwise indications.
- G. Air sensors and transmitters shall have an extended range of 20 percent above Project design flow and 20 percent below minimum Project flow to signal abnormal flow conditions and to provide flexibility for changes in operation.
- H. Liquid and steam sensors, meters, and transmitters shall have an extended range of 20 percent above Project design flow and 20 percent below Project minimum flow to signal abnormal flow conditions and to provide flexibility for changes in operation.
- I. Environmental Conditions:
 - 1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
 - a. If instrument alone cannot meet requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated and cooled, filtered, and ventilated as required by instrument and application.

2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures.

2.2 BALL-STYLE CONTROL VALVES

A. Ball Valves with Single Port and Characterized Disk:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Belimo Aircontrols (USA), Inc.
 - b. Bray Commercial Division
 - c. Johnson Controls
2. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
3. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
4. Close-off Pressure: 200 psig.
5. Process Temp Range: for water temperature up to 284 °F and saturated steam up to 15 psi.
6. Body and Tail Piece: Cast bronze ASTM B 61, ASTM B 62, ASTM B 584, or forged brass with nickel plating.
7. End Connections: Threaded (NPT) ends.
8. Ball: Stainless Steel
9. Stem and Stem Extension:
 - a. Material to match ball.
 - b. Blowout-proof design.
 - c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.
10. Ball Seats: Reinforced PTFE.
11. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
12. Flow Characteristic: Equal percentage.

2.3 RECTANGULAR CONTROL DAMPERS

A. General Requirements:

1. Unless otherwise indicated, use parallel blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed blade configuration.
2. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.
3. Damper actuator shall be factory installed by damper manufacturer as integral part of damper assembly. Coordinate actuator location and mounting requirements with damper manufacturer.

B. Rectangular Dampers with Aluminum Airfoil Blades:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Ruskin Company.
 - b. Johnson Controls.
 - c. Vent Products.
2. Performance:
 - a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure.
 - b. Pressure Drop: 0.05-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.
 - c. Velocity: Up to 6000 fpm.
 - d. Temperature: Minus 40 to plus 185 deg F.
 - e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
 - f. Damper shall have AMCA seal for both air leakage and air performance.
3. Construction:
 - a. Frame:
 - 1) Material: ASTM B 211, Alloy 6063 T5 extruded-aluminum profiles, 0.07 inch thick.
 - 2) Hat-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch.
 - 3) Width not less than 5 inches.
 - b. Blades:
 - 1) Hollow, airfoil, extruded aluminum.
 - 2) Parallel or opposed blade configuration as required by application.
 - 3) Material: ASTM B 211, Alloy 6063 T5 aluminum, 0.07 inch thick.
 - 4) Width not to exceed 6 inches.
 - 5) Length as required by close-off pressure, not to exceed 48 inches.
 - c. Seals:
 - 1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
 - 2) Jambs: Stainless steel, compression type.
 - d. Axles: 0.5-inch-diameter plated steel, mechanically attached to blades.
 - e. Bearings:
 - 1) Molded synthetic or stainless-steel sleeve mounted in frame.
 - 2) Where blade axles are installed in vertical position, provide thrust bearings.
 - f. Linkage:
 - 1) Concealed in frame.
 - 2) Constructed of aluminum and plated steel.
 - 3) Hardware: Stainless steel.

g. Transition:

- 1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
- 2) Factory mount damper in a sleeve with a close transition to mate to field connection.
- 3) Damper size and sleeve shall be connection size plus 2 inches.
- 4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
- 5) Sleeve material shall match adjacent duct.

2.4 ROUND CONTROL DAMPERS

A. Round Dampers, Sleeve Type:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Ruskin Company.
 - b. Johnson Controls.
 - c. Vent Products.
2. Performance:
 - a. Leakage: Leakage shall not exceed 0.15 cfm/in. of perimeter blade at 4-in. wg differential static pressure.
 - b. Pressure Drop: 0.02-in. wg at 1500 fpm across a 12-inch damper when tested according to AMCA 500-D, figure 5.3.
 - c. Velocity: Up to 4000 fpm.
 - d. Temperature: Minus 25 to plus 200 deg F.
 - e. Pressure Rating: Equal to or greater than pressure rating of ductwork, but minimum of 8-in. wg for sizes through 12 inches, and minimum of 6-in. wg for larger sizes.
3. Construction:
 - a. Frame:
 - 1) Material: Galvanized steel, 0.04 in thick.
 - 2) Outward rolled stiffener beads positioned approximately 1 inch inboard of each end.
 - 3) Sleeve-type connection for mating to adjacent ductwork.
 - 4) Size Range: 4 to 24 inches.
 - 5) Length not less than 7 inches.
 - 6) Provide 2-inch sheet metal stand-off for mounting actuator.
 - b. Blade: Double-thickness circular flat blades sandwiched together and constructed of galvanized steel.
 - c. Blade Seal: Polyethylene foam seal sandwiched between two sides of blades and fully encompassing blade edge.
 - d. Axle: 0.5-inch-diameter plated steel, mechanically attached to blade.
 - e. Bearings: Stainless-steel sleeve pressed into frame.

2.5 ELECTRIC AND ELECTRONIC CONTROL VALVE AND DAMPER ACTUATORS

- A. Actuators shall operate related valves and dampers with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.
- B. Actuators shall produce sufficient power and torque to close off or open against the maximum system pressures encountered. Actuators shall be sized to close off or open against the shutoff pressure as a minimum requirement.
- C. Position indicator and graduated scale on each actuator.
- D. Type: Motor operated, with or without gears, electric and electronic.
- E. Voltage: 24-V ac.
- F. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
- G. Function properly within a range of 85 to 120 percent of nameplate voltage.
- H. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.
- I. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.
- J. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.
- K. Provide mounting hardware and linkages for connecting actuator to damper.
- L. Select actuators to fail in desired position in the event of a power failure.
- M. Construction:
 - 1. For Actuators Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
 - 2. For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.
 - 3. For Actuators Larger Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
- N. Field Adjustment:
 - 1. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.
 - 2. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.
- O. Two-Position Actuators: Single direction, spring return or reversing type.
- P. Modulating Actuators:

1. Operation: Capable of stopping at all points across full range and starting in either direction from any point in range.
2. Control Input Signal:
 - a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position and other input drives actuator to close position. No signal of either input remains in last position.
 - b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for V dc 4- to 20-mA signals.
 - c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to pulse duration (length) of signal from a dry contact closure, triac sink, or source controller.
 - d. Programmable Multi-Function:
 - 1) Control Input, Position Feedback, and Running Time: Factory or field programmable.
 - 2) Diagnostic: Feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
 - 3) Service Data: Include, at a minimum, number of hours powered and number of hours in motion.

Q. Position Feedback:

1. Equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
2. Equip modulating actuators with a position feedback through current signal for remote monitoring.
3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

R. Fail-Safe:

1. Where indicated, provide actuator to fail to an end position.
2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

S. Integral Overload Protection:

1. Provide against overload throughout the entire operating range in both directions.
2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

T. Valve and Damper Attachment:

1. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve shaft without the need for connecting linkages.
2. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.
3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

U. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

V. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with heater and control where required by application.

W. Stroke Time:

1. Operate valve and damper from fully closed to fully open within 15 seconds.
2. Operate valve and damper from fully open to fully closed within 15 seconds.
3. Move valve and damper to failed position within 15 seconds.
4. Select operating speed to be compatible with equipment and system operation.
5. Actuators operating in smoke control systems shall comply with governing code and NFPA requirements.

X. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

2.6 AIR TEMPERATURE SENSORS

A. Platinum RTDs: Common Requirements:

1. 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:
 - a. Range: Minus 50 to 275 deg F.
 - b. Interchangeable Accuracy: At 32 deg F within 0.5 deg F.
 - c. Repeatability: Within 0.5 deg F.
 - d. Self-Heating: Negligible.
4. Transmitter Requirements:
 - a. Transmitter required for each 100-ohm RTD.
 - b. Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

B. Platinum RTD, Single-Point Air Temperature Duct Sensors:

1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F.
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches.
5. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
6. Gasket for attachment to duct or equipment to seal penetration airtight.

7. Conduit Connection: 1/2-inch

C. Platinum RTD, Air Temperature Averaging Sensors:

1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F.
3. Multiple sensors to provide average temperature across entire length of sensor.
4. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
5. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.
6. Length: As required by application to cover entire cross section of air tunnel.
7. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
8. Gasket for attachment to duct or equipment to seal penetration airtight.
9. Conduit Connection: 1/2-inch

D. Platinum RTD Outdoor Air Temperature Sensors:

1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F.
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Solar Shield: Stainless steel.
5. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
6. Conduit Connection: 1/2-inch trade size.

E. Platinum RTD Space Air Temperature Sensors:

1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 212 deg F.
3. Sensor assembly shall include a temperature sensing element mounted under a bright white, non-yellowing, plastic cover.
4. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
5. Concealed wiring connection.
6. Space Temperature Sensors

- a. Room sensors shall have the following options except for spaces noted in item 6.b below:

- 1) Set point reset slide switch or button providing a +/-3 degree (adjustable) range.
- 2) Individual heating/cooling set point slide switches.
- 3) A momentary override request push button for activation of after hours operation

- b. Room sensors for corridors, common areas, vestibules, locker/shower, and toilet rooms shall have a blank surface-mounted stainless steel wall plate. Set point adjustments shall be made via the BMS head end system.

7. Space Temperature Sensors with Integral Display

- a. Room sensors for offices and conference rooms shall have an integral LCD display and four button keypad with the following capabilities:

- 1) Display room and outside air temperatures.
- 2) Display and adjust room comfort set point.
- 3) Display and adjust fan operation status.
- 4) Timed override request push button with LED status for activation of after hours operation.
- 5) Display controller mode
- 6) Password selectable adjustment of set point and override modes.

2.7 COMBINATION AIR TEMPERATURE SENSOR AND SWITCH

- A. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.
- B. Combination temperature sensor and switch in same instrument.
- C. Air Temperature Switch:
 1. Factory preset set point of 38 deg F. Field-adjustable set point from 30 to 44 deg F.
 2. Responsive to coldest 12-inch section of sensor length.
 3. DPST latching relay rated at 25 A and 120-V ac, with powered controller, coil, and manual reset at panel. Wire one leg to fan start circuit and other leg to signal a remote alarm.
- D. Air Temperature Sensor:
 1. Temperature-averaging type over sensor length. Length to be determined by installing trade to provide uniform coverage over air tunnel. Consult manufacturer for recommendations.
 2. Platinum RTD with a value of 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
 3. Accuracy: Within 0.9 deg F.
 4. Output Signal: 4 to 20 mA for connection to remote monitoring.
 5. Encase RTDs in a flexible nominal 0.375-inch-diameter sheath constructed of brass.
 6. Lead wires shall be 18-gage AWG copper.
 7. Enclosure: NEMA 250, Type 4.

2.8 AIR TEMPERATURE SWITCHES

- A. Thermostat and Switch for Low Temperature Control in Duct Applications:
 1. Description:
 - a. Two-position control.
 - b. Field-adjustable set point.
 - c. Manual reset.
 - d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Performance:
 - a. Operating Temperature Range: 15 to 55 deg F.
 - b. Temperature Differential: 5 deg F, non-adjustable and additive.
 - c. Enclosure Ambient Temperature: Minus 20 to 140 deg F.
 - d. Sensing Element Maximum Temperature: 250 deg F.
 - e. Voltage: 120-V ac.

- f. Current: 16 FLA.
 - g. Switch Type: Two SPDT snap switches operate on coldest 12-inch section along element length.
- 3. Construction:
 - a. Vapor-Filled Sensing Element: Nominal 20 feet long.
 - b. Dual Temperature Scale: Fahrenheit and Celsius visible on face.
 - c. Set-Point Adjustment: Screw.
 - d. Enclosure: Painted metal, NEMA 250, Type 1.
 - e. Electrical Connections: Screw terminals.
 - f. Conduit Connection: 1/2-inch trade size.

2.9 AIR TEMPERATURE RTD TRANSMITTERS

- A. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.
- B. House electronics in NEMA 250 enclosure.
 - 1. Duct: Type 1.
 - 2. Outdoor: Type 4.
 - 3. Space: Type 1.
- C. Conduit Connection: 1/2-inch
- D. Functional Characteristics:
 - 1. Input:
 - a. 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
 - b. 1000-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
 - 2. Span (Adjustable):
 - a. Space: 40 to 90 deg F.
 - b. Supply Air Cooling and Heating: 40 to 120 deg F.
 - c. Supply Air Cooling Only: 40 to 90 deg F.
 - d. Supply Air Heating Only: 40 to 120 deg F.
 - e. Return Air: 50 to 100 deg F.
 - f. Mixed Air: Minus 40 to 140 deg F.
 - g. Outdoor: Minus 40 to 140 deg F.
 - 3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
 - 4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.
 - 5. Match sensor with temperature transmitter and factory calibrate together.
- E. Performance Characteristics:
 - 1. Calibration Accuracy: Within 0.1 percent of the span.

2. Stability: Within 0.2 percent of the span for at least 6 months.
3. Combined Accuracy: Within 0.5 percent.

2.10 MOISTURE SENSORS AND TRANSMITTERS

A. Sensors and Transmitters with Digital Display:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Vaisala.
 - b. Penn.
 - c. Johnson Controls
2. Performance:
 - a. Accuracy including non-linearity, hysteresis, and repeatability: Within 2 percent from zero to 90 percent relative humidity and within 2.5 percent from 90 to 100 percent relative humidity when operating between 60 to 77 deg F.
 - b. Relative Humidity Range: Zero to 100 percent.
 - c. Factory calibrated and NIST traceable with certificate included.
3. Construction:
 - a. Provide housing with integral sensor for room applications.
 - b. Provide housing with remote sensor probe for ducted applications.
 - 1) Duct Sensor Body: 300 series stainless steel or chrome-plated aluminum, at least 2 inches long for duct-mounted applications.
 - 2) Provide sensor with cable for field installation in conduit.
 - 3) For duct-mounted applications, thread the sensor assembly for connection to a threaded mounting flange.
 - c. Provide general-purpose humidity sensor unless application requires special requirements. Provide sensor with sintered stainless-steel filter for duct applications.
 - d. Housing shall be ABS/PC plastic or powder-coated aluminum.
 - e. Housing Classification: NEMA 250, Type 4 or 4X.
 - f. Provide housing with wall-mounting plate.
4. Output Signal: 2-wire, 4- to 20-mA output signal with a drive capacity of at least 500 ohms at 24-V dc.
5. Provide unit with a digital display of relative humidity in percent.

B. Sensor and Transmitter without Display:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Vaisala.
 - b. Penn.
 - c. Johnson Controls
2. Performance:

- a. Accuracy including non-linearity, hysteresis, and repeatability: Within 2 percent from zero to 90 percent relative humidity and within 3 percent from 90 to 95 percent relative humidity when operating at 68 deg F.
 - b. Relative Humidity Range:
 - 1) Duct: Zero to 100 percent.
 - 2) Space: Zero to 95 percent relative.
 - c. Factory calibrated and NIST traceable with certificate included.
 - 3. Construction for Space Applications:
 - a. Housing with integral sensor.
 - b. Housing shall be ABS plastic or powder-coated aluminum.
 - c. Enclosure: NEMA 250, Type 4.
 - d. Provide housing with a wall-mounting plate.
 - 4. Construction for Duct and Equipment Applications:
 - a. Housing with integral sensor.
 - b. Duct Sensor Body: 300 series stainless steel.
 - c. Provide sensor with sintered stainless-steel filter for duct applications.
 - d. Housing shall be cast aluminum.
 - e. Enclosure: NEMA 250, Type 4.
 - 5. Output Signal: Two-wire, 4- to 20-mA output signal with drive capacity of at least 500 ohms at 24-V dc.
- 2.11 COMBINATION HUMIDITY AND TEMPERATURE SENSOR AND TRANSMITTER WITH DISPLAY:
- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Vaisala.
 - 2. Penn.
 - 3. Johnson Controls
 - B. Description:
 - 1. Factory package consisting of humidity and temperature sensor, digital display, keypad user interface, installation hardware, interconnecting sensor cabling, installation instructions, and operating manual.
 - 2. Each transmitter shall be individually calibrated and provided with NIST traceable calibration certifications.
 - 3. Provide a service cable for connecting to a notebook computer and Microsoft Windows compatible software.
 - C. Display:
 - 1. Alphanumeric display of the following on the face of the enclosure:
 - a. Percent relative humidity.
 - b. Absolute humidity.
 - c. Mixing ratio.

- d. Dry-bulb temperature.
 - e. Wet-bulb temperature.
 - f. Dew point temperature.
 - g. Enthalpy.
 - 2. Visual display of measurement trends, and minimum and maximum values over a one-year period.
- D. Electronics Enclosure:
- 1. Integral to sensors for wall- (room-)mounted applications and remote from temperature and humidity sensors for duct and equipment applications.
 - 2. NEMA 250, Type 4 or 4X.
 - 3. Labeled terminal strip for field wiring connections.
- E. Output Signals:
- 1. Three Analog Outputs: 4 to 20 mA.
- F. Temperature Sensor:
- 1. Temperature range matched to application, but not less than minus 40 to 140 deg F.
 - 2. Within 0.5 deg F accuracy over the temperature range of 50 to 100 deg F and within 1 deg F over the remainder of the range.
 - 3. Provide duct installation kit for duct applications.
- G. Humidity Sensor:
- 1. Relative Humidity Measurement Range: Zero to 100 percent.
 - 2. Response time in still air within 40 seconds.
 - 3. Accuracy including non-linearity, hysteresis, and repeatability:
 - a. For Temperature between Minus 4 and 104 Deg F: Within 1 percent plus 0.008 times relative humidity reading.
 - 4. Sintered, stainless-steel filter, protecting sensor.
 - 5. Provide duct installation kit for duct applications.
- H. Power Supply:
- 1. Field Power: 24-V ac, unless otherwise required by the application.
 - 2. Internal Power: As required by transmitter.
- 2.12 AIR-PRESSURE SENSORS
- A. Duct Traverse Static Pressure Sensor:
- 1. Sensor shall traverse the duct cross section and have at least one pickup point every 6 inches along length of sensor.
 - 2. Construct sensor of 18-gage Type T6063-T5 extruded and anodized aluminum.
 - 3. Sensor supported with threaded rod, sealing washer, and nut at one end and a mounting plate with gasket at other end.
 - 4. Mounting plate with threaded, NPS 3/8 compression fitting for connection to tubing.
 - 5. Accuracy within 1 percent of actual operating static pressure.

6. Dual offset static sensor design shall provide accurate sensing of duct static pressure in the presence of turbulent and rotational airflows with a maximum 30-degree yaw and pitch.
7. Suitable for velocities of 100 to 10000 fpm and temperatures of up to 200 deg F.
8. Sensor air resistance shall be less than 0.1 times the velocity pressure at probe-operating velocity.
9. Suitable for flat oval, rectangular, and round duct configurations.

B. Space Static Pressure Sensor for Wall Mounting:

1. Aluminum wall plate with perforated center arranged to sense space static pressure. Exposed surfaces are provided with brush finish.
2. Wall plate provided with screws and sized to fit standard single-gang electrical box.
3. Back of sensor plate fitted with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, and 0.125-inch fitting for tubing connection.
4. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm from a 360-degree radial source.

C. Space Static Pressure Sensor for Recessed Ceiling Mounting:

1. Aluminum round plate with perforated center arranged to sense space static pressure. Exposed surfaces provided with brush finish.
2. Sensor intended for flush mount on face of ceiling with pressure chamber recessed in ceiling plenum.
3. Back of sensor plate fitted with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, and 0.125-inch fitting for concealed tubing connection.
4. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm from a 360-degree radial source.

D. Space Static Pressure Sensor for Exposed or Suspended Mounting:

1. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm from a 360-degree radial source.
2. Aluminum with perforations arranged to sense space static pressure. Exposed surfaces provided with brush finish.
3. Sensor fitted with multiple sensing ports, pressure impulse suppression chamber, and airflow shielding.
4. Surface-mounted sensor provided with solid mounting plate intended for mount to ceiling with pressure chamber exposed to view.
5. Surface-mounted sensor with 0.125-inch fitting for exposed tubing connection.
6. Suspended sensor intended for pendent mount with pressure chamber exposed to view.
7. Suspended sensor with NPS 1/2 fitting for exposed pipe or tubing connection.

2.13 AIR-PRESSURE SWITCHES

A. Air-Pressure Differential Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Dwyer Instruments, Inc.
 - b. Johnson Controls, Inc.
 - c. Cleveland Controls.
 - d. Penn.

2. Diaphragm operated to actuate an SPDT snap switch.
 - a. Fan safety shutdown applications: Switch with manual reset.
3. Electrical Connections: Three-screw configuration, including one screw for common operation and two screws for field-selectable normally open or closed operation.
4. Enclosure Conduit Connection: Knock out or threaded connection.
5. User Interface: Screw-type set-point adjustment located inside removable enclosure cover.
6. High and Low Process Connections: Threaded, NPS 1/8.
7. Enclosure:
 - a. Dry Indoor Installations: NEMA 250, Type 1.
 - b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
 - c. Hazardous Environments: Explosion proof.
8. Operating Data:
 - a. Electrical Rating: 15 A at 120- to 480-V ac.
 - b. Pressure Limits:
 - 1) Continuous: 45 inches wg.
 - 2) Surge: 10 psig.
 - c. Temperature Limits: Minus 30 to 180 deg F.
 - d. Operating Range: Approximately 2 times set-point.
 - e. Repeatability: Within 3 percent.
 - f. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.14 AIR-PRESSURE TRANSMITTERS

A. Air-Pressure Differential Transmitter:

1. Performance:
 - a. Range: Approximately 2 times set point.
 - b. Accuracy: Within 1 percent of the full-scale range.
 - c. Hysteresis: Within 0.10 percent of full scale.
 - d. Repeatability: Within 0.05 percent of full scale.
 - e. Stability: Within 1 percent of span per year.
 - f. Overpressure: 10 psig.
 - g. Temperature Limits: Zero to 150 deg F.
 - h. Compensate Temperature Limits: 40 to 150 deg F.
 - i. Thermal Effects: 0.033 percent of full scale per degree F.
 - j. Shock and vibration shall not harm the transmitter.
2. Output Signals:
 - a. Analog Current Signal:
 - 1) Two-wire, 4- to 20-mA dc current source.
 - 2) Signal capable of operating into 800-ohm load.
3. Display: Four-digit digital display with minimum 0.4-inch-high numeric characters.
4. Operator Interface: Zero and span adjustments located behind cover.
5. Construction:
 - a. Plastic casing with removable plastic cover.
 - b. Threaded, NPS 1/4 swivel fittings for connection to copper tubing or NPS 3/16 barbed fittings for connection to polyethylene tubing. Fittings on bottom of instrument case.

- c. Screw terminal block for wire connections.
- d. Vertical plane mounting.
- e. NEMA 250, Type 4.
- f. Provide mounting bracket suitable for installation.

2.15 POSITION LIMIT SWITCHES

- A. Description: Select type of actuating head (plunger, roller lever, or rod) to suit application.
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Performance:
 - 1. Life expectancy: Not less than 30 million mechanical operations and 750,000 electrical operations.
 - 2. Operating Frequency: 300 mechanical operations per minute and 30 electrical operations per minute.
 - 3. Voltage: 120-, and 480- V ac or 24- V dc, as required by application.
 - 4. Current Rating: As required by application.
 - 5. Temperature Rise: 50 deg C.
 - 6. Ambient Temperature: 14 to 175 deg F.
 - 7. Ambient Relative Humidity: 35 to 95 percent.
- C. Construction:
 - 1. NEMA 250, Type 4X enclosure.
 - 2. Switch Type: SPDT or DPDT, as required by application.
 - 3. Status indicator integral to switch. Field switchable to light when contacts are actuated and operating, or contacts are free and not operating.
 - 4. Electrical Connection: Screw or plug-in terminals.
 - 5. Conduit Connection: NPS 1/2.

2.16 AIRFLOW SENSORS

- A. Air Flow Monitoring
 - 1. Fan Inlet and Outside Airflow Measuring Stations
 - a. At the inlet of each supply and return fan, airflow traverse probes shall be provided that shall continuously monitor the fan air volumes and system velocity pressure. Conform to ASTM Standard D3464-75 to set the minimum number of sampling points dependent on the cross-section size of the sampling port.
 - b. Minimum outside air volumes shall be controlled by a thermal dissipation type airflow controller due to very low tolerable pressure drops. Ebtron, GreenTrol, FMT, or equal, integrated with a controlling damper and analog output signal for closed-loop control.
 - c. Each fan inlet traverse probe shall be of a dual manifolded, cylindrical, type 3003 extruded aluminum configuration, having an anodized finish to eliminate surface pitting and unnecessary air friction. The multiple total pressure manifold shall have sensors located along the stagnation plane of the approaching air flow. The manifold should not have forward projecting sensors into the airstream. The static pressure manifold shall incorporate dual offset static tops on the opposing sides of the averaging manifold so as to be insensitive to flow-angle variations of as much as + 20° in the approaching airstream.
 - d. The air flow traverse probe shall not induce a measurable pressure drop, nor system effect, nor shall the sound level within the duct be amplified by its singular or multiple presence in the airstream. Each airflow measuring probe shall contain multiple total and static pressure sensors placed at equal distances along the probe length. The number of sensors on each probe and the quantity of probes

- utilized at each installation shall comply with the ASHRAE Standards for duct traversing.
- e. Due to adverse system effects, fixed probe types will not be acceptable on the inlets of mixed flow fans. A thermal dissipation or remote in-duct means shall be used instead.
- f. Air flow measuring stations shall be manufactured by Air Moni-tor Corp. (Model FI), Tek-Air Systems, Inc., Ebtron, Dietrich Standard, or equal.
- 2. Single Probe Air Flow Measuring Sensor
 - a. The single probe air flow measuring sensor shall be duct mounted with an adjustable sensor insertion length of up to eight inches. The transmitter shall produce a 4-20 mA or 0-10VDC signal linear to air velocity. The sensor shall be a hot wire anemometer and utilize two temperature sensors and a heater element temperature. The other sensor shall measure the downstream air temperature. The temperature differential shall be directly related to air flow velocity.
- 3. Shielded Static Air Probe
 - a. A shielded static pressure probe shall be provided at each end of the building and where indicated on plans to provide indoor to outdoor static pressure references. The probe shall have multiple sensing ports, an impulse suppression chamber, and airflow shielding. A suitable probe for indoor and outdoor locations shall be provided.
 - b. Indoor reference probes/sensors shall be provided in spaces noted in sequence of operation.

2.17 AIRFLOW SWITCHES

- A. Differential pressure flow switches shall be bellows actuated switches or snap acting micro-switches with appropriate scale range and differential adjustment for intended service. Mercury switches will not be acceptable.
- B. Acceptable manufacturers: Johnson Controls, Cleveland Controls, Dwyer Instruments, Penn.

2.18 LIQUID FLOW SWITCHES

- A. Water flow switches shall be equal to Johnson Controls P74 or W.E. Anderson Model V6.

2.19 LEAK DETECTION SWITCHES

- A. Solid State, Point-Type, Leak-Detection Switch:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Veris Industries.
 - b. W. E. Anderson; Dwyer Instruments, Inc.
 - c. Reliance Detection Technologies
 - 2. Features: Audible and visual alarm with relay output for remote indication.
 - 3. Alarm activated based on change in resistance.
 - 4. Performance:
 - a. Service: Water.
 - b. Temperature Limits: 32 to 122 deg F.
 - c. Switch Type: SPDT relay.
 - d. Electric Connection: Cable attached.
 - e. Adjustable water depth sensitivity with a minimum range of 0.1" to 0.25".
 - 5. Construction: Acrylic, ABS plastic.
 - 6. Field Power: 24-V ac or dc.
- B. Solid State, Cable-Type, Leak-Detection Switch:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. W. E. Anderson; Dwyer Instruments, Inc.
 - b. Veris Industries
 - c. Reliance Detection Technologies
2. Control Module Features:
 - a. Power and alarm LEDs.
 - b. Alarm test switch.
 - c. Continuous tape integrity self-check.
3. Performance:
 - a. Service: Water, or other conductive liquid.
 - b. Switch Type: DPDT.
 - c. Electric Connection: Screw terminals.
 - d. Conduit Connection: 0.5 inch.
4. Construction:
 - a. Control Module Enclosure: Extruded aluminum.
 - b. Tape: Hydrophobic with connector on each end.
 - c. Tape Length: As required for application. Field extendable.
5. Field Power: 24-V ac or V dc.

2.20 CARBON DIOXIDE (CO2) SENSORS

- A. CO2 sensor shall be either wall or duct mounted as shown in the design and shall utilize a non-dispersive infrared (NDIR) sensing method to provide a direct readout of CO2 levels over range of 0 to 2000 ppm. Sensor shall provide a linear output signal that can be linked to BCS.
- B. CO2 sensor shall have the following characteristics:
 1. Gas Detected: Carbon Dioxide (CO2).
 2. Sensing Method: Single-beam, non-dispersive infrared (NDIR).
 3. Measurement Range: 0 to 2000 ppm.
 4. Accuracy: Plus, or minus 5 percent of reading and plus or minus 50 ppm at 77 degrees F.
 5. Max Annual Drift: 20 ppm (nominal).
 6. Repeatability: Plus, or minus 20 ppm.
 7. Output Drift: Maximum 2 percent of full range.
 8. Operating Range:
 - a. Humidity: 5 to 95 percent RH, non-condensing.
 - b. Temperature: 32 to 104 degrees F.
 9. Output Signal:
 - a. Current: 4 to 20 mA dc.
 10. Response Time: 1 minute to 90 percent of step change.
 11. Calibration:
 - a. Adjustment: Zero and span.
 - b. Interval: By usage, one (1) year maximum recommended.
 12. Mounting: Space or duct as required.
- C. Approved Manufacturer:
 1. Vaisala.
 2. Honeywell.
 3. Johnson Controls.
 4. Siemens.
 5. BAPI.

2.21 LOCAL UNIT CONTROL PANELS

- A. Panels shall be NEMA 1 (if located indoors) or NEMA 4 (if located outdoors) enclosures at least 24 inches wide, 12 inches high and a minimum of 8 inches deep or 6 inches deep in finished spaces, with a locking door. Total panel, including removable backplate for equipment mounting, shall be made rust-resistant and painted with epoxy enamel. All door locks shall operate from a common key.
- B. Other control devices shall be located inside panel and mounted to allow sufficient space for both interconnecting pneumatic tubing and wiring. Interior panel tubing and wiring shall be arranged in a systematic, orderly manner and brought to terminal blocks for connection of field wiring. Low-voltage and line-voltage terminals shall be isolated from each other.
- C. Furnish Record Drawings in a plastic pocket affixed inside panel to show systems and devices controlled from panel.

2.22 WEATHERSHIELDS

- A. Provide appropriate weather housings for temperature and Relative Humidity sensors installed outdoors.
- B. Housings shall prevent sun from directly striking sensors and shall not radiate to sensors. Provide adequate ventilation so that sensor responds to ambient environmental conditions of surrounding.
- C. Shields shall be compatible with surface on which they are installed. Housings shall be as indicated.

2.23 CONTROL RELAYS

- A. Control relays shall be of electro-mechanical type with coils for 120 V ac, 60 Hz power, and shall have contacts suitable for required load without contact bounce.
- B. Relays shall have normally-open (N. O.) and normally-closed (N. C.) contacts, as required, with quantity of poles required to perform indicated functions.
- C. Approved Manufacturers:
 - 1. Potter-Brumfield.
 - 2. Agastat.
 - 3. Magnecraft.
 - 4. IDEC.

2.24 INSTRUMENTATION CABLE

- A. Cable shall be designed for transmitting a two-wire current signal over required distance.
- B. Cable shall contain two (2) conductors, 7 strands each, 100 percent shielded in an aluminum-polyester foil shield, and one (1) stranded conductor drain wire. Conductors shall be NO. 18 AWG wire covered with minimum 15 mil thick fire-retardant PVC insulation. Drain wire shall be No. 20 AWG. All wires shall be encased in a minimum 35 mil thick fire-retardant PVC jacket.
- C. Cable shall be UL listed PLTC for 300-volt operation.
- D. Approved Manufacturers:

1. Belden.
2. Alpha.
3. Dekron.

2.25 PLENUM CABLE

- A. In areas served by mechanical ventilation or air handling systems where space above ceiling acts as an air plenum and local codes permit, provide plenum cable specifically formulated and manufactured for low-smoke and low-flame spread classification in place of other insulated wire in conduit, if desired.
- B. Power-limited circuit cable (CLZP) shall be UL listed for Class 2 circuits installed as wiring within plenum of a building, shall be resistant to spread of fire, shall have low smoke characteristics, and shall have been subjected to and passed UL 910.
- C. Paragraph 727-38b (3) of NFPA 70 shall apply.
- D. Cable can be installed without conduit in plenums.
- E. Acceptable conductor insulation types are:
 1. Teflon FEP (Fluorinated ethylene propylene).
 2. Halar E-CTFE (Ethylene chlorotrifluoroethylene).
 3. Kynar PVDF (Polyvinylidene fluoride).
- F. Acceptable manufacturers are:
 1. Dekoron by Fluorocarbon/Samuel Moore Group.
 2. Alpha Wire Corporation.
 3. Ausimont USA, Inc.
 4. Belden Wire and Cable.

2.26 WIRING AND TERMINALS

- A. Electrical wiring within equipment cabinets shall be neatly arranged in Panduit, properly supported, and terminated on one (1) side of terminal blocks only so that external connections for control, instrumentation, and auxiliary power can be made to other side of terminal blocks inside each equipment cabinet. Instrument connections shall be protected in a NEMA 1 enclosure, unless in a damp or wet location, in which a NEMA 4 enclosure shall be used in accordance with NEPA 70. No connections shall be exposed.
- B. At least 20 percent spare unused terminals shall be provided in each group of terminal blocks. Control circuits and power circuits shall be completely separated by use of divided or separate terminal blocks. Terminal blocks for external connections shall be General Electric, Weidmuller, Phoenix Contact or Woertz, designed to accommodate up to No. 12 AWG cable. No more than 2 wires shall be connected to any one (1) terminal block screw. Wire connections shall be made with horseshoe or ring-tongue compression terminals unless terminal block is specifically designed for bare wire connection. Stranded wire shall connect to terminal block with insulated ferrules. Label terminal blocks and each device termination.

2.27 CURRENT TRANSFORMERS

- A. Provide a donut-type current transformer with a 0 to 5 ampere ac output.
- B. Current transformer shall be compatible with current transducers specified below.

2.28 CURRENT TRANSDUCERS

- A. Current transducer shall accept standard 0 to 5 amps ac input (150 V ac maximum) from a current transformer (CT). Input signal isolation shall be provided by a single-turn primary input transformer. Overload capability shall be 35 amps for 30 seconds.
- B. Unit output shall be a 4 to 20 mA dc signal (or other standard process current or voltage signal compatible with BCS) proportional to input current.
- C. Unit shall be powered from a 120 V ac, 60 Hz source. (Units requiring dc voltages shall be provided with 120 v ac/0 to 60 V dc power supply).
- D. Unit shall have an adjustable zero and span, with ripple less than 10 mV P/P maximum span and load.
- E. Approved Manufacturers:
 - 1. Moore Industries, Inc.
 - 2. DEVAR, Inc., Control Products Division.
 - 3. Rochester Instrument System (with dc power supply).
 - 4. Neilson-Kuljian.

2.29 CURRENT-SENSING RELAYS

- A. Current-sensing relays shall provide a normally-open contact rated at a minimum of 50 volts peak and 1/2 ampere or 25 VA, non-inductive.
- B. There shall be a single hole for passage of current-carrying conductors.
- C. Devices shall be sized for operation at 50 percent rated current based on connected load.
- D. Voltage isolation shall be a minimum of 600 volts.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for instruments installed in piping and ductwork to verify actual locations of piping connections before installation.
- C. Confirm that proposed mounting locations comply with requirements indicated and approved submittals.
 - 1. Indicate dimensioned locations with mounting height for all surface-mounted products to walls and ceilings on shop drawings.
 - 2. Do not begin installation without submittal approval of mounting location.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Furnish and install products required to satisfy most stringent requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Properly support valves, dampers, actuators, instruments, tubing, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
- D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- E. Firestop penetrations made in fire-rated assemblies and seal penetrations made in acoustically rated assemblies.
- F. Fastening Hardware:
 - 1. Stillson wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- H. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.
- I. Provide required control and interlock wiring, including Eps, Pes, freezestats, smoke detectors, fire alarms (other than power), fan interlocks, control panels, and other devices for a complete and operable system, and as described System Sequences of Operation.
- J. Provide pilot-duty relays as required for interlocking of equipment as described in Sequences of Operation.
- K. Verify quantity and size of tubing and wiring required for systems.
- L. If a field-mounted device or piece of equipment requires 120 V ac service and is mounted at a difference location from 120 Vac power source provided under Electrical: Division 26, provide extensions to power wiring, including conduit, junction boxes, and other hardware, in accordance with Electrical: Division 26. This requirement shall also apply to devices powered by 24 V or greater.
- M. Thermostats, temperature sensors, humidistats and humidity sensors located on exterior walls shall be mounted on back-insulated blocks.
- N. Provide wiring of freezestats and smoke detectors into control circuit of fans.

- O. Demonstrate to Owner's Representative that field wiring is installed in accordance with Electrical: Division 26 and is properly connected to appropriate device(s) as indicated and as described in Building Control System Sequences of Operation.
- P. Provide, at each duct thermostat and temperature sensor and where else indicated, direct-reading duct thermometers that are readable by a person standing on floor so that thermostat/sensor operation can be checked.
- Q. Install control panels so that they are stable and fully supported. Locate panels a minimum of 1 inch from wall.
- R. Air handling unit duct smoke detectors will be furnished under Electrical: Division 26 and mounted under Duct Accessories: Division 23. Conduit and wiring from each duct smoke detector to individual fan starter will be provided under Electrical: Division 26. Provide all final connections at fan starter for each air handling unit as indicated. Final connections at duct smoke detector end will be normally-closed contacts and will be made under Electrical: Division 26.
- S. Power wiring to control panels, will be provided under Electrical: Division 26.
- T. Provide labor for coordination and preparation during testing and balancing of systems as performed under Testing and Balancing of Mechanical System.
- U. If control panels are placed at locations different from those indicated, extend related accessories, including housekeeping pads and power wiring, and other tubing and wiring, to new locations and make required connections required at new locations. Provide additional electrical wiring and related equipment other than that provided under Electrical: Division 26 in accordance with DDC System manufacturer's written recommended instructions.
- V. If more control panels than those indicated are required, indicated requirements shall apply to additional panels.
- W. Control panels are indicated on HVAC plans for approximate location and space allocation only and are not indicated dimensionally or quantitatively. Total quantity of control panels required shall be determined by actual point capacities and spare point requirements as indicated. Provide related accessories, including extension of housekeeping pads, and power wiring to additional control panels.
- X. Provide required cooperation and coordination with Electrical: Division 26 such that power and ground wiring is provided in accordance with DDC System equipment manufacturer's written recommendations. DDC System supplier/installer shall make final electrical connections to DDC System equipment.
- Y. Coordinate with Electrical: Division 26 and associated Electrical Contract Documents to verify which items of DDC System Equipment require un-interruptible power supply (UPS) power. Provide individual and total DDC System equipment KVA load to Division 26 in order to ensure proper UPS and feeder capacity. Provide air compressor motor load data to Electrical Installer for coordination of feeder capacity.
- Z. For NEMA 12 cabinets, provide electrical isolation between cooling fan and thermostat and electronics in cabinet such that cooling fan operation does not affect FEP operation. Provide means to drain cooling equipment condensate without piping along floors, walkways or exits.

- AA. At penetrations through designated vapor-retardant walls, as indicated on Architectural Drawings, provide patching and sealant with silicone sealant in accordance with Division 7. Also provide air and vaportight sealing of shielded air probes (SAPs) with silicone sealant.
- BB. Temperature:
 - 1. Freezestats: Provide one (1) freezestat for each 20 square feet of coil free area.
 - 2. RTDs: RTDs may be used in ducts, piping or spaces. When RTD is installed in pipes, it shall be installed in a thermowell. Coordinate thermowell locations with Mechanical Installer. When installed in airstreams or spaces, RTDs shall be rigidly supported. RTDs used for space-temperature sensing shall include a housing suitable for wall mounting. RTDs used for outside-air sensing shall have an instrument shall have an instrument shelter to minimize solar effects and shall be mounted to isolate building thermal effects. RTD assemblies shall be readily accessible and installed in such a manner as to allow for easy replacement. Sensors located outdoors shall be NEMA 4 rated.
- CC. Humidity:
 - 1. Relative Humidity: Provide air guards/sintered filters when there are air flows greater than 50 fpm across sensor element. Sensors located outdoors shall be NEMA 4 rated.
- DD. Test field equipment in conjunction with Building Control System (BCS).

3.3 ELECTRIC POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 GROUNDING

- A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 CONTROL VALVES

- A. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.
- B. Install flanges or unions to allow drop-in and -out valve installation.
- C. Where indicated, install control valve with three-valve bypass manifold to allow for control valve isolation and removal without interrupting system flow by providing manual throttling valve in bypass pipe.
- D. Valve Orientation:
 - 1. Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15 degrees off of vertical, not inverted.

2. Install valves in a position to allow full stem movement.

E. Clearance:

1. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
2. Install valves with at least 12 inches of clear space around valve and between valves and adjacent surfaces.

F. Threaded Valves:

1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
2. Align threads at point of assembly.
3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.

3.6 CONTROL DAMPERS

- A. Install smooth transitions, not exceeding 15 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.

B. Clearance:

1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
2. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.

C. Service Access:

1. Dampers and actuators shall be accessible for visual inspection and service.
2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 233300 "Air Duct Accessories."

- D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.

- E. Attach actuator(s) to damper drive shaft.

- F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

3.7 TEMPERATURE, RELATIVE HUMIDITY AND PRESSURE INSTRUMENT INSTALLATIONS

A. Mounting Location:

1. Roughing In:
 - a. Outline instrument mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
 - b. Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.
 - 1) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.
 - 2) Do not begin installation without submittal approval of mounting location.

- c. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.
 2. Install switches and transmitters associated with individual air-handling units and connected ductwork and piping in air-handling unit system control panel to provide service personnel a single and convenient location for inspection and service.
 3. Install switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 4. Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
- B. Special Mounting Requirements:
 1. Protect products installed outdoors from solar radiation, building and wind effect with stand-offs and shields constructed of Type 316 stainless.
 2. Instruments having performance impacted by temperature and relative humidity of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.
 3. Temperature sensors installed in public areas shall be provided with lockable covers to prevent tampering.
- C. Mounting Height:
 1. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
 2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
 - a. Mount at 48 inches to adhere to ADA requirements.
- D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.
- E. Space Sensor Installation:
 1. Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.
 2. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
 3. In finished areas, recess electrical box within wall.
 4. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.
 5. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.
- F. Outdoor Air Sensor Installation:
 1. Mount sensor in a discrete location facing north.
 2. Protect installed sensor from solar radiation and other influences that could impact performance.
 3. If required to have a transmitter, mount transmitter remote from sensor in an accessible and serviceable location indoors.
- G. Single-Point Sensor Installation:

1. Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed in center of duct cross section and located to sense near average temperature. Do not exceed 24 inches in sensor length.
 2. Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.
 3. Rigidly support sensor to duct and seal penetration airtight.
 4. If required to have transmitter, mount transmitter remote from sensor at accessible and serviceable location.
- H. Averaging Duct Temperature Sensor Installation:
1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar equipment, and large ducts with air tunnel cross-sectional area of 20 sq. ft. and larger.
 2. Install sensor length to maintain coverage over entire cross-sectional area. Install multiple sensors where required to maintain the minimum coverage.
 3. Fasten and support sensor with manufacturer-furnished clips to keep sensor taut throughout entire length.
 4. If required to have transmitter, mount transmitter in an accessible and serviceable location.
- I. Low-Limit Air Temperature Switch Installation:
1. Install multiple low-limit switches to maintain coverage over entire cross-sectional area of air tunnel.
 2. Fasten and support sensing element with manufacturer-furnished clips to keep element taut throughout entire length.
 3. Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.
 4. Install on entering side of cooling coil unless otherwise indicated on Drawings.
- J. Duct Pressure Sensors:
1. Install sensors using manufacturer's recommended upstream and downstream distances.
 2. Unless indicated on Drawings, locate sensors approximately 67 percent of distance of longest hydraulic run. Location of sensors shall be submitted and approved before installation.
 3. Install mounting hardware and gaskets to make sensor installation airtight.
 4. Route tubing from the sensor to transmitter.
 5. Use compression fittings at terminations.
 6. Install sensor in accordance with manufacturer's instructions.
 7. Support sensor to withstand maximum air velocity, turbulence, and vibration encountered to prevent instrument failure.
- K. Air-Pressure Differential Switches:
1. Install air-pressure sensor in system for each switch connection. Install sensor in an accessible location for inspection and replacement.
 2. A single sensor may be used to share a common signal to multiple pressure instruments.
 3. Install access door in duct and equipment to access sensors that cannot be inspected and replaced from outside.
 4. Route NPS 3/8 tubing from sensor to switch connection.
 5. Do not mount switches on rotating equipment.
 6. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
 7. Install switches in an easily accessible location serviceable from floor.
 8. Install switches adjacent to system control panel if within 50 feet; otherwise, locate switch in vicinity of system connection.

3.8 FLOW INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

- A. Install per manufacturer's installation instructions.

3.9 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification.

3.10 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.
- B. Wash and shine glazing.
- C. Polish glossy surfaces to a clean shine.

3.11 CHECKOUT PROCEDURES

- A. Instrumentation Checkout: Perform the following for all instruments including control valves and dampers:
 - 1. Check installed products before continuity tests, leak tests, and calibration.
 - 2. Check each instrument for proper location and accessibility.
 - 3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
 - 4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
- B. Control Valve Checkout:
 - 1. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
 - 2. Verify that control valves are installed correctly for flow direction.
 - 3. Verify that valve body attachment is properly secured and sealed.
 - 4. Verify that valve actuator and linkage attachment are secure.
 - 5. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
 - 6. Verify that valve ball, disc, and plug travel are unobstructed.
 - 7. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.
- C. Control-Damper Checkout:
 - 1. Verify that control dampers are installed correctly for flow direction.
 - 2. Verify that proper blade alignment, either parallel or opposed, has been provided.
 - 3. Verify that damper frame attachment is properly secured and sealed.
 - 4. Verify that damper actuator and linkage attachment are secure.
 - 5. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
 - 6. Verify that damper blade travel is unobstructed.
- D. Temperature and Humidity Instrument Checkout:

1. Verify sensing element type and proper material.
2. Verify location and length.
3. Verify that wiring is correct and secure.

E. Flow Instrument Checkout

1. Verify that sensors are installed correctly with respect to flow direction.
2. Verify that sensor attachment is properly secured and sealed.
3. Verify that processing tubing attachment is secure and isolation valves have been provided.
4. Inspect instrument tag against approved submittal.
5. Verify that recommended upstream and downstream distances have been maintained.

3.12 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
4. Equipment and procedures used for calibration shall meet instrument manufacturer's written instructions.
5. Provide diagnostic and test equipment for calibration and adjustment.
6. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
8. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
9. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistance source.

C. Digital Signals:

1. Check digital signals using a jumper wire.
2. Check digital signals using an ohmmeter to test for contact.

D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

E. Switches: Calibrate switches to make or break contact at set points indicated.

F. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.

2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.
 - G. Stroke and adjust control valves and dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
 - H. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.
 - I. For control valves and dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.
- 3.13 [INSTRUMENT APPLICATIONS]
- 3.14 MAINTENANCE AND SERVICE
- A. General Requirements: Provide services, and provide materials, and equipment required for successful operation of entire system and appurtenances for a period of one (1) year after Date of Acceptance by Owner and Design Professional. System acceptance shall be defined as full completion of testing and performance verified by Owner's Representative and sign-off of acceptance.
 - B. Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by manufacturer's authorized service representative. Include quarterly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
 - C. Emergency Service: Supplier/Installer furnish services of a Technical Representative capable of servicing equipment at Project Site before end of working day when service call is made prior to noon. Supplier/Installer furnish services of a Technical Representative capable of servicing equipment at Project Site before noon of next working day when service call is made after noon or during evening or weekend.
 - D. Personnel: Advise Owner's Representative in writing of names of designated service representative and of service personnel. Update this list when there are changes in personnel.
 1. Supervision: During maintenance and service, furnish services of a supervisor with full authority to act for Supplier/Installer. Supervisor shall effect daily liaison during normal working hours with Owner.
 2. Service Personnel: Provide qualified service personnel to adjust and repair system.
- 3.15 DEMONSTRATION
- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

END OF SECTION

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SECTION 230923

DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. DDC or system for monitoring and controlling of HVAC systems.
 - 2. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.
- B. Related Requirements:
 - 1. Section 230993 "Sequence of Operations for HVAC DDC" for control sequences.
 - 2. Section 230910 "Instrumentation and Control Equipment" for instrumentation and control equipment requirements.

1.3 DEFINITIONS

- A. Algorithm: A logical procedure for solving a recurrent mathematical problem. A prescribed set of well-defined rules or processes for solving a problem in a finite number of steps.
- B. Analog: A continuously varying signal value, such as current, flow, pressure, or temperature.
- C. BACnet Specific Definitions:
 - 1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data over and services over a network.
 - 2. BACnet Interoperability Building Blocks (BIBBs): BIBB defines a small portion of BACnet functionality that is needed to perform a particular task. BIBBs are combined to build the BACnet functional requirements for a device.
 - 3. BACnet/IP: Defines and allows using a reserved UDP socket to transmit BACnet messages over IP networks. A BACnet/IP network is a collection of one or more IP subnetworks that share the same BACnet network number.
 - 4. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.
 - 5. PICS (Protocol Implementation Conformance Statement): Written document that identifies the particular options specified by BACnet that are implemented in a device.
- D. BAS: Building Automation System.
- E. BMS: Building Management System.

- F. Binary: Two-state signal where a high signal level represents ON" or "OPEN" condition and a low signal level represents "OFF" or "CLOSED" condition. "Digital" is sometimes used interchangeably with "Binary" to indicate a two-state signal.
- G. Controller: Generic term for any standalone, microprocessor-based, digital controller residing on a network, used for local or global control. Three types of controllers are indicated: Network Controller, Programmable Application Controller, and Application-Specific Controller.
- H. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing of enterprise system.
- I. COV: Changes of value.
- J. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.
- K. Distributed Control: Processing of system data is decentralized, and control decisions are made at subsystem level. System operational programs and information are provided to remote subsystems and status is reported back. On loss of communication, subsystems shall be capable of operating in a standalone mode using the last best available data.
- L. DOCSIS: Data-Over Cable Service Interface Specifications.
- M. E/P: Voltage to pneumatic.
- N. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.
- O. HLC: Heavy load conditions.
- P. I/O: System through which information is received and transmitted. I/O refers to analog input (AI), binary input (BI), analog output (AO) and binary output (BO). Analog signals are continuous and represent control influences such as flow, level, moisture, pressure, and temperature. Binary signals convert electronic signals to digital pulses (values) and generally represent two-position operating and alarm status. "Digital," (DI and (DO), is sometimes used interchangeably with "Binary," (BI) and (BO), respectively.
- Q. I/P: Current to pneumatic.
- R. LAN: Local area network.
- S. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- T. Modbus TCP/IP: An open protocol for exchange of process data.
- U. MS/TP: Master-slave/token-passing, IEE 8802-3. Datalink protocol LAN option that uses twisted-pair wire for low-speed communication.
- V. MTBF: Mean time between failures.
- W. Network Controller: Digital controller, which supports a family of programmable application controllers and application-specific controllers that communicates on peer-to-peer network for transmission of global data.

- X. Network Repeater: Device that receives data packet from one network and rebroadcasts it to another network. No routing information is added to protocol.
- Y. PDA: Personal digital assistant.
- Z. Peer to Peer: Networking architecture that treats all network stations as equal partners.
- AA. POT: Portable operator's terminal.
- BB. RAM: Random access memory.
- CC. RF: Radio frequency.
- DD. Router: Device connecting two or more networks at network layer.
- EE. Server: Computer used to maintain system configuration, historical and programming database.
- FF. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.
- GG. UPS: Uninterruptible power supply.
- HH. USB: Universal Serial Bus.
- II. User Datagram Protocol (UDP): This protocol assumes that the IP is used as the underlying protocol.
- JJ. VAV: Variable air volume.
- KK. WLED: White light emitting diode.

1.4 ACTION SUBMITTALS

A. Multiple Submissions:

1. If multiple submissions are required to execute work within schedule, first submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.
2. Clearly identify each submittal requirement indicated and in which submission the information will be provided.
3. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.

B. Product Data: For each type of product include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.

4. Installation, operation, and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product. Including but not limited to:
 - a. Operator workstation.
 - b. Gateways.
 - c. DDC controllers.
 - d. Enclosures.
 - e. Electrical power devices.
 - f. Accessories.
 - g. Instruments.
 - h. Control dampers and actuators.
 - i. Control valves and actuators.
 - j. Temperature sensors and T-Stats.
 - k. Relative humidity sensors.
6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.
8. Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.
9. Schedule and design calculations for control dampers and actuators.
 - a. Flow at Project design and minimum flow conditions.
 - b. Face velocity at Project design and minimum airflow conditions.
 - c. Pressure drop across damper at Project design and minimum airflow conditions.
 - d. AMCA 500-D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
 - e. Maximum close-off pressure.
 - f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
 - g. Torque required at worst case condition for sizing actuator.
 - h. Actuator selection indicating torque provided.
 - i. Actuator signal to control damper (on, close or modulate).
 - j. Actuator position on loss of power.
 - k. Actuator position on loss of control signal.
10. Schedule and design calculations for control valves and actuators.
 - a. Flow at Project design and minimum flow conditions.
 - b. Pressure-differential drop across valve at Project design flow condition.
 - c. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.
 - d. Design and minimum control valve coefficient with corresponding valve position.
 - e. Maximum close-off pressure.
 - f. Leakage flow at maximum system pressure differential.
 - g. Torque required at worst case condition for sizing actuator.
 - h. Actuator selection indicating torque provided.
 - i. Actuator signal to control damper (on, close or modulate).
 - j. Actuator position on loss of power.
 - k. Actuator position on loss of control signal.
11. Schedule and design calculations for selecting flow instruments.

- a. Instrument flow range.
- b. Project design and minimum flow conditions with corresponding accuracy, control signal to transmitter and output signal for remote control.
- c. Extreme points of extended flow range with corresponding accuracy, control signal to transmitter and output signal for remote control.
- d. Pressure-differential loss across instrument at Project design flow conditions.
- e. Where flow sensors are mated with pressure transmitters, provide information for each instrument separately and as an operating pair.

C. Software Submittal:

1. Cross-referenced listing of software to be loaded on operator workstation, server, gateway, and DDC controller.
2. Description and technical data of all software provided and cross-referenced to products in which software will be installed.
3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
4. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
5. Description of system database, including all data included in database, database capacity and limitations to expand database.
6. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

D. LEED Submittals:

1. Include supporting data showing energy, flow, moisture, motion, pressure, and temperature instruments, where and if used in Project; and associated application for monitoring and control to satisfy requirements of Project LEED credits.
 - a. Indicate applicable locations and area coverage, control set points, description of control operation and other required information to satisfy submission requirements for award of LEED credit.
2. Organize and identify standalone, supporting data for each LEED credit.
3. Project LEED credits include the following:
 - a. Advanced Energy Metering
 - b. Thermal Comfort

E. Shop Drawings:

1. General Requirements:
 - a. Include cover drawing with Project name, location, Owner, Engineer, Contractor, and issue date with each Shop Drawings submission.
 - b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
 - c. Prepare Drawings using CAD.

2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Plan Drawings indicating the following:
 - a. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork, and piping.
 - b. Room names and numbers with coordinated placement to avoid interference with control products indicated.
 - c. Operator workstation, server, gateway, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller.
 - d. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
 - e. Network communication cable and raceway routing.
 - f. Proposed routing of wiring, cabling, conduit, and tubing, coordinated with building services for review before installation.
4. Schematic drawings for each controlled HVAC system indicating the following:
 - a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
 - b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
 - c. A graphic showing location of control I/O in proper relationship to HVAC system.
 - d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
 - e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
 - f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays, and interface to DDC controllers.
 - g. Narrative sequence of operation.
 - h. Graphic sequence of operation, showing all inputs and output logical blocks.
5. Control panel drawings indicating the following:
 - a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
 - b. Interior subpanel layout, drawn to scale and showing all internal components, cabling, and wiring raceways, nameplates and allocated spare space.
 - c. Front, rear, and side elevations and nameplate legend.
 - d. Unique drawing for each panel.
6. DDC system network riser diagram indicating the following:
 - a. Connections points into the existing DDC System.
 - b. Each device connected to network with unique identification for each.
 - c. Interconnection of each different network in DDC system.
 - d. For each network, indicate communication protocol, speed, and physical means of interconnecting network devices, such as copper cable type, or fiber-optic cable type. Indicate raceway type and size for each.
 - e. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

7. DDC system electrical power riser diagram indicating the following:
 - a. Each point of connection to field power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
 - b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
 - c. Each product requiring power with requirements (volts/phase/hertz/amperes/connection type) listed for each.
 - d. Power wiring type and size, race type, and size for each.
8. Color graphics indicating the following:
 - a. Itemized list of color graphic displays to be provided.
 - b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
 - c. Intended operator access between related hierarchical display screens.

F. System Description:

1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
3. System and product operation under each potential failure condition including, but not limited to, the following:
 - a. Loss of power.
 - b. Loss of network communication signal.
 - c. Loss of controller signals to inputs and outputs.
 - d. Operator workstation failure.
 - e. Server failure.
 - f. Gateway failure.
 - g. Network failure
 - h. Controller failure.
 - i. Instrument failure.
 - j. Control damper and valve actuator failure.
 - k. Temperature sensor failure.
4. Complete bibliography of documentation and media to be delivered to Owner.
5. Description of testing plans and procedures.
6. Description of Owner training.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. Manufacturer's qualification data.
2. Testing agency's qualifications data.

B. Product Test Reports: For each product that requires testing to be performed by a qualified testing agency.

- C. Preconstruction Test Reports: For each separate test performed.
- D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.
 - 1. In addition to items specified in Division 1 "Operation and Maintenance Data," include the following:
 - a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
 - b. Testing reports and checklists of completed final versions of reports, checklists, and trend logs.
 - c. As-built versions of submittal Product Data.
 - d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
 - e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
 - f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
 - g. Engineering, installation, and maintenance manuals that explain how to:
 - 1) Design and install new points, panels, and other hardware.
 - 2) Perform preventive maintenance and calibration.
 - 3) Debug hardware problems.
 - 4) Repair or replace hardware.
 - h. Backup copy of graphic files, programs, and database on electronic media such as flash drives.
 - i. List of recommended spare parts with part numbers and suppliers.
 - j. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
 - k. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
 - l. Licenses, guarantees, and warranty documents.
 - m. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
 - n. Owner training materials.

1.7 QUALITY ASSURANCE

- A. The Building Management System (BMS) herein specified shall be fully integrated and installed as a complete package by the Building Management System Sub-subcontractor. The system shall include all wiring (plenum rated, wire-in-conduit, CAT 6, low voltage power or other related controls dedicated wiring), installation supervision, calibration, adjustments, and checkout necessary for a complete and fully operational system. All low voltage ATC wiring shall be color coded using a unique color wire not used by any other system. Coordinate as required.

B. DDC System Provider Qualifications:

1. Authorized representative of, and trained by, DDC system manufacturer.
2. Demonstrated past experience with installation of DDC system products being installed for period within five consecutive years before time of bid.
3. Each person assigned to Project shall have demonstrated past experience.
4. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
5. Service and maintenance staff assigned to support Project during warranty period.
6. Product parts inventory to support on-going DDC system operation for a period of not less than 5 years after Substantial Completion.
7. The ATC/DDC subcontractor shall be qualified by the Commonwealth of Massachusetts, Division of Capital Asset Management and Maintenance (DCAMM) in the field of Energy Management Systems with a single project limit equal to or greater than their contract amount.
8. The ATC/DDC subcontractor shall have a dedicated service department focused solely on supporting their customer base in the efficient and effective maintenance and operation of their BAS and HVAC systems which shall include:
 - a. Full time dedicated Service Support Engineers available to remotely support the energy Dept. of BPS personnel. this support must be available on a 15-minute notice during normal working hours.
 - b. Shall employ a minimum of ten (10) full time dedicated Service Automation Technicians who are resident within twenty-five (25) mile of the jobsite.
 - c. All automation specialists/technicians must be furnished with service trucks/vans with an inventory of replacement components and parts and necessary tools to properly service and support the ATC/DDC systems installed under this project
 - d. The ATC/DDC subcontractor must be available for service and system support 24 hours per day, 365 days per year. All service and support requests must be responded to within two (2) hours.

1.8 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.
1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
 2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.
 - a. Install updates only after receiving Owner's written authorization.
 3. Warranty service shall occur during normal business hours and commence within 24 hours of Owner's warranty service request.
 4. Provide five working days (40 hours) of programming for Owner-directed topics during the warranty period.
 5. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

- A. Approved manufacturers/systems subject to compliance with the requirements shall be one of the following or equal:
 - 1. Distech/Acuity brands by Control Technologies, Inc.
 - 2. Johnson Controls FX
 - 3. WEBs/Honeywell by TEC Systems
 - 4. Talon by Siemens
 - 5. SmartStruxure by Schneider

2.2 DDC SYSTEM DESCRIPTION

- A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.
 - 1. DDC system shall consist of a high-speed, peer-to-peer network of distributed DDC controllers, other network devices, operator interfaces, and software.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. The control system shall consist of all sensors, thermostats, temperature transmitters, controllers, automatic valves and dampers, damper operators, switches, control panels, network routers, bridges, surge suppressors, power conditioners, uninterruptible power supplies (UPS) and other accessory equipment along with a complete system of air piping and electrical control wiring to fill the intent of the specifications and provide for a complete and operable system. All control equipment shall be fully proportioning, except as noted otherwise.
- D. The HVAC drawings and specifications indicate the primary scope of systems to be controlled. In addition, select plumbing and electrical systems shall be controlled, monitored, alarmed, and otherwise integrated as herein specified.

2.3 INCIDENTAL WORK BY OTHERS

- A. The following incidental work shall be furnished under DIVISION 26 by the designated contractor under the supervision of the controls contractor.
 - 1. The Electrical Subcontractor shall:
 - a. Provide, on magnetic starters furnished under DIVISION 26, all necessary auxiliary contacts, with buttons and switches in the required configurations.
 - b. Provide duct smoke detectors and power wiring to the detectors.
 - c. Provide 120V power where shown on the electrical drawings, to ATC panels, within distributed junction boxes above ceilings for terminal boxes, dampers, control valves, and miscellaneous ATC functions. Also provide 120V power at air handling units and mechanical rooms dedicated to ATC use. Where 120V power is required for automatic temperature controls, but not shown on the electrical plans, the ATC Subcontractor shall provide it. Power feeds to direct digital controllers; panels and central hardware shall be from dedicated independent

power circuits. Power conditioning shall be provided by the ATC Sub-contractor as indicated herein. All control system power shall be connected to the standby power system for controls operation during a power disruption. Coordinate as required.

2. The Sheetmetal Sub-subcontractor shall:

- a. Install all automatic dampers and smoke dampers.
- b. Provide necessary blank-off plates (safing) required to install dampers that are smaller than duct size.
- c. Assemble multiple section dampers with required inter-connecting linkages and extend required number of shafts through duct for external mounting or damper motors.
- d. Provide necessary sheetmetal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation and affix and seal permanently in place only after stratification problem has been eliminated.
- e. Provide access doors in duct or other approved means of access through ducts for service to control equipment/
- f. Install furnished sensors and devices in ductwork and air handling units.

3. The HVAC Subcontractor shall:

- a. Install automatic control valves and separable wells that are specified to be furnished by the ATC Subcontractor.
- b. Provide all necessary valved pressure taps, water, drain and overflow connections, and piping.
- c. Provide, on magnetic starters furnished under DIVISION 23, all necessary auxiliary contacts, with buttons and switches in the required configuration.

2.4 WEB ACCESS

A. DDC system shall be Web compatible.

1. Web-Compatible Access to DDC System:

- a. Operator workstation and server shall perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.
- b. DDC system shall support Web browser access to building data. Operator using a standard Web browser shall be able to access control graphics and change adjustable set points.
- c. Web access shall be password protected.
- d. Workstation may be Thin Client or WYSE terminal
- e. Provide Wireless access point in all electrical and mechanical rooms. Coordinate with owner or IT vendor/designer.
- f. Wireless access shall support smart tablets and phones.

2. Performance Requirements

B. System Performance Objectives:

1. DDC system shall manage HVAC and Lighting Control systems.
2. DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.

3. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
 4. DDC system shall operate while unattended by an operator and through operator interaction.
 5. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.
- C. Surface-Burning Characteristics: Products installed in ducts, equipment, and return-air paths shall comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
1. Flame-Spread Index: 25 or less.
 2. Smoke-Developed Index: 50 or less.
- D. Network Bandwidth: Design each network of DDC system to include at least 30 percent available spare bandwidth with DDC system operating under normal and heavy load conditions indicated. Calculate bandwidth usage and apply a safety factor to ensure that requirement is satisfied when subjected to testing under worst case conditions.
- E. DDC System Data Storage:
1. Include server(s) with disk drive data storage to archive not less than 24 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends and other information indicated.
 2. When logged onto a server, operator shall be able to also interact with any DDC controller connected to DDC system as required for functional operation of DDC system.
 3. Server(s) shall be used for application configuration; for archiving, reporting, and trending of data; for operator transaction archiving and reporting; for network information management; for alarm annunciation; and for operator interface tasks and controls application management.
 4. Server(s) shall use IT industry-standard database platforms such as Microsoft SQL Server and Microsoft Data Engine (MSDE).
- F. Future Expandability:
1. DDC system size shall be expandable to an ultimate capacity of at least 25% of total I/O points indicated.
 2. Additional DDC controllers, I/O and associated wiring shall be all that is needed to achieve ultimate capacity. Initial network infrastructure shall be designed and installed to support ultimate capacity.
 3. Operator interfaces installed initially shall not require hardware and software additions and revisions for ultimate capacity.
- G. Input Point Displayed Accuracy: Input point displayed values shall meet following end-to-end overall system accuracy, including errors associated with meter, sensor, transmitter, lead wire or cable, and analog to digital conversion.
1. Energy:
 - a. Thermal: Within 3 percent of reading.
 - b. Electric Power: Within 1 percent of reading.
 - c. Requirements indicated on Drawings for meters not supplied by utility.
 2. Flow:

- a. Air: Within 2 percent of design flow rate.
 - b. Water: Within 2 percent of design flow rate.
- 3. Moisture (Relative Humidity):
 - a. Air: Within 5 percent RH.
 - b. Space: Within 5 percent RH.
 - c. Outdoor: Within 5 percent RH.
- 4. Pressure:
 - a. Air, Ducts and Equipment: 1 percent of instrument span.
 - b. Water: Within 1 percent of instrument span.
- 5. Speed: Within 5 percent of reading.
- 6. Temperature (Dry Bulb, Wet Bulb and Dew Point):
 - a. Air: Within 1 deg F.
 - b. Space: Within 1 deg F.
 - c. Outdoor: Within 2 deg F.
 - d. Water: Within 1 deg F.
- H. Performance Standards: System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).
 - 1. Graphic Display: A graphic with 20 dynamic points shall display with current data within 10 sec.
 - 2. Graphic Refresh: A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.
 - 3. Configuration and Tuning Screens: Screens used for configuring, calibrating, or tuning points, control loops, and similar control logic shall automatically refresh with 6 sec.
 - 4. Alarm Response Time: An object that goes into alarm shall be annunciated at the workstation within 15 sec.
 - 5. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.
 - 6. Performance: Programmable controllers shall be able to completely execute DDC SYSTEM control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.
 - 7. Multiple Alarm Annunciations: Each workstation on the network shall receive alarms within 5 sec. of other workstations.
- I. Data Base Update: Under normal system operation, the Workstation Equipment point data base shall be updated so that any change in analog value or digital status is no older than ten (10) seconds.
- J. Environmental Conditions for Controllers, Gateways, and Routers:
 - 1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.
 - a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance.

Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.

2. Products shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Products not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Installed location shall dictate the following NEMA 250 enclosure requirements:
 - a. Outdoors, Protected: Type 3.
 - b. Outdoors, Unprotected: Type 4.
 - c. Indoors, Heated with Ventilation: Type 2.
 - d. Indoors, Heated and Air Conditioned: Type 1.
 - e. Mechanical Equipment Rooms: Type 4
 - f. Within Duct Systems and Air-Moving Equipment: Type 4.

K. Backup Power Source:

1. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source.

L. UPS:

1. Power the following DDC system products by UPS units:
 - a. Server.
 - b. Gateways.
 - c. DDC controllers.

M. Continuity of Operation after Electric Power Interruption:

1. Automatic Restart: Entire DDC System shall have automatic restart software that causes system to actuate automatic restart without human intervention after an electrical power outage and UPS battery drain and subsequent restart.
 - a. Workstation Equipment Power Failure: During normal operation, each workstation shall continuously update all system information on its own hard drive. Provide safeguard procedures to assure that any interruptions of power during the updating procedure will not destroy memory record of any data file already on the drive. During each update procedure, a time tag shall be stored in a file with current month, day, hour and minute. At time of power failure at workstation equipment, all workstation equipment shall go through an orderly shutdown such that no system information and/or programming information is destroyed or lost. Upon power restoration after a power failure, each workstation shall restart. Power failure at workstation equipment shall not affect control functions of BCU(s).
 - b. DDC System Power Failure: Provide safeguard procedures to assure that any interruptions of power during operation of DDC System will not cause a loss of any programming information and/or stored database information from input devices. At the time of power failure at DDC System all functions of DDC System shall shutdown orderly (and without damaging any connected equipment) such that all connected equipment shall either be positioned to "Fail Safe" mode or be de-energized and cease to operate. Upon power restoration and after a power

failure, DDC System shall generate an automatic restart command which shall cause DDC System to restart, and DDC System shall automatically restart and DDC System shall automatically restart corresponding software, including adjustment of all optimum start-stop and schedule start-stop programs. DDC System shall review all programs that should have been executed during power failure and shall energize appropriate equipment sequentially. DDC System shall resort each point to proper state as if power failure has not occurred (except for update of current time and date). All major electrical loads shall be sequentially restarted with adjustable time delays.

- N. Power Line Surge Protection: Protect equipment power supplies from power line surges to 1000 V ac rms. Provide protection of equipment at ground potential to ensure protection against surges. Transient surge protection shall be incorporated into design/manufacture of each RCP/ASC/TCU and operator's workstation to protect electrical components. Do not use fuses for surge protection.
- O. Communication Links Surge Protection: Protect communications equipment against surges induced on any communications link to 1000 V ac rms. Cables and conductors which serve as communications links between BAS OWS, Servers, Network Controllers and Remote-Control Panels shall have surge protection circuits installed at each end. Do not use fuses for surge protection.

2.5 DDC SYSTEM OPERATOR INTERFACES

- A. Functionality described in this paragraph shall be provided at the CEMOC facility.
- B. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:
 - 1. New Desktop and portable operator workstation with hardwired connection through LAN port.
 - 2. Remote connection using outside of system personal computer or PDA through Web access.
 - 3. Remote connection using portable operator workstation and modem.
- C. Access to system, regardless of operator means used, shall be transparent to operator.
- D. Network Ports: For hardwired connection of desktop or portable operator workstation. Network port shall be easily accessible, properly protected, clearly labeled, and installed at the following locations:
 - 1. Custodian's office.
- E. Desktop Workstation:
 - 1. Connect to DDC system LAN through a communications port directly on LAN or through a communications port on a DDC controller.
 - 2. Able to communicate with any device located on any DDC system LAN.
 - 3. Able to communicate, with modems, remotely with any device connected to any DDC system LAN.
 - 4. Communication via a modem shall not interfere with LAN activity and LAN activity shall not prevent workstation from handling incoming calls.
- F. Portable Workstations:

1. Connect to DDC system Level one LAN through a communications port directly on LAN or through a communications port on a DDC controller.
2. Able to communicate with any device located on any DDC system LAN.
3. Connect to DDC system LAN through a communications port on an application-specific controller, or a room temperature sensor connected to an application-specific controller.
4. Portable workstation shall be able to communicate with any device connected to any system LAN regardless of point of physical connection to system.
5. Monitor, program, schedule, adjust set points, and report capabilities of I/O connected anywhere in system.
6. Have dynamic graphic displays that are identical to desktop workstations.

G. POT:

1. Connect DDC controller through a communications port local to controller.
2. Able to communicate with any DDC system controller that is directly connected to DDC system.

H. Critical Alarm Reporting:

1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
2. DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.
3. DDC system shall notify recipients by any or all means, including e-mail, text message and prerecorded phone message to mobile and landline phone numbers.

- I. Simultaneous Operator Use: Capable of accommodating up to five simultaneous operators that are accessing DDC system through any one of operator interfaces indicated.

2.6 NETWORKS

- A. Acceptable networks for connecting operator workstations and network controllers include the following:

1. IP.
2. IEEE 8802-3, Ethernet.

2.7 NETWORK COMMUNICATION PROTOCOL

- A. Network communication protocol(s) used throughout entire DDC system shall be open to public and available to other companies for use in making future modifications to DDC system.

B. ASHRAE 135 Protocol:

1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.
2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

C. Industry Standard Protocols:

1. DDC system shall use any one or a combination of the following industry standard protocols for network communication while complying with other DDC system requirements indicated:
 - a. ASHRAE 135.
 - b. Modbus Application Protocol Specification V1.1b.
2. Operator workstations and network controllers shall communicate through ASHRAE 135 protocol.
3. Portions of DDC system networks using ASHRAE 135 communication protocol shall be an open implementation of network devices complying with ASHRAE 135. Network devices shall be tested and listed by BACnet Testing Laboratories.
4. Portions of DDC system networks using Modbus Application Protocol Specification V1.1b communication protocol shall be an open implementation of network devices and technology complying with Modbus Application Protocol Specification V1.1b.
5. Gateways shall be used to connect networks and network devices using different protocols.

2.8 DESKTOP OPERATOR WORKSTATIONS

A. Performance Requirements:

1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
2. Energy Star compliant.

B. Personal Computer:

1. Minimum Processor Speed: 3.3 gigahertz.
2. RAM:
 - a. Capacity: 24 GB.
 - b. Expandable Capacity: 24 GB.
3. Hard Drive:
 - a. Number of Hard Drives: Two.
 - b. Capacity: 1 TB each.
4. Optical Read and Write Drive:
 - a. Include with at least 2 MB of data buffer.
 - b. Type: HD.
 - c. Average access time of 150 ms or less.
 - d. MTBF of at least 100,000 power-on hours.
5. At least four expansion slots of 64 bit.
6. Video Card:
 - a. Resolution: 1920 by 1200 pixels.
 - b. RAM: 8 GB.

7. Sound Card:
 - a. At least 128 voice wavetable synthesis.
 - b. Capable of delivering three-dimensional sound effects.
 - c. High-resolution 16-bit stereo digital audio recording and playback with user-selectable sample rates up to 48,000 Hz.
 8. Network Interface Card: Include card with connection, as applicable.
 - a. 10-100-1000 base TX Ethernet with RJ45 connector port.
 - b. 100 base FX Ethernet with SC or ST port.
 9. Modem:
 - a. Ethernet connectivity.
 10. I/O Ports:
 - a. Two USB 3.0 ports on front panel, six on back panel, and three internal on motherboard.
 - b. One serial port.
 - c. One parallel port.
 - d. Two PS/2 ports.
 - e. One RJ-45.
 - f. One stereo line-in and headphone line-out on back panel.
 - g. One microphone and headphone connector on front panel.
 - h. One IEEE 1394 on front and back panel with PCI-e card.
 - i. One ESATA port on back panel.
 11. Battery: Life of at least three years to maintain system clock/calendar and ROM, as a minimum.
- C. Keyboard:
1. 101 enhanced keyboard.
 2. Full upper- and lowercase ASCII keyset, numeric keypad, dedicated cursor control keypad, and 12 programmable function keys.
 3. Wireless operation within up to 72 inches in front of workstation.
- D. Pointing Device:
1. Either a two- or three-button mouse.
 2. Wireless operation within up to 72 inches in front of workstation.
- E. Flat Panel Display Monitor:
1. Display:
 - a. Color display with 21 inches diagonal viewable area.
 - b. Digital or analog input signal.
 - c. Aspect Ratio: 16 to 9.
 - d. Antiglare display.
 - e. Dynamic Contrast Ratio: 50000 to 1.
 - f. Tilt adjustable base.

- g. Energy Star compliant.
- h. Resolution: 1920 by 1080 pixels at 60 Hz with pixel size of 0.277 mm or smaller.
- i. Number of Displays: One.

F. Speakers:

- 1. Two, with individual controls for volume, bass, and treble.
- 2. Signal to Noise Ratio: At least 65 dB.
- 3. Power: At least 4 W per speaker/channel.
- 4. Magnetic shielding to prevent distortion on the video monitor.

G. I/O Cabling: Include applicable cabling to connect I/O devices.

2.9 SERVERS

A. Performance Requirements:

- 1. Performance requirements may dictate equipment exceeding minimum requirements indicated.
- 2. Energy Star compliant.
- 3. Minimum Processor Speed: 3.3 gigahertz.
- 4. RAM:
 - a. Capacity: 24GB.
 - b. Expandable Capacity: 24 GB.
- 5. Redundant Array of Independent Disks: Two configuration.
- 6. Drive Bays: Eight at 2.5 inches or eight at 3.5 inches.
- 7. Hard-Drive Storage: Three drives each with 2 TB storage and nominal rotational speed of 7200 rpm.
- 8. Network Interface: Dual port Ethernet.
- 9. DVD +RW Drive.
- 10. Keyboard and mouse.
- 11. Next-day on-site warranty for two-year period following Substantial Completion.

B. Servers shall include the following:

- 1. Full-feature backup server (server and backup minimum requirement).
- 2. Software licenses.
- 3. CAT-6 cable installation between server(s) and network.

C. Web Server:

- 1. If required to be separate, include Web server hardware and software to match, except backup server is not required.
- 2. Firewalls between server Web and networks.
- 3. Password protection for access to server from Web server.
- 4. CAT 6 cable installation between the server(s) and building Ethernet network.

D. Power each server through a 3,000 VA UPS unit.

2.10 SYSTEM SOFTWARE

A. System Software Minimum Requirements:

1. Real-time multitasking and multiuser 64-bit operating system that allows concurrent execution of multiple real-time programs and custom program development.
2. Operating system shall be capable of operating Microsoft Windows applications.
3. Database management software shall manage all data on an integrated and non-redundant basis. Additions and deletions to database shall be without detriment to existing data. Include cross linkages so no data required by a program can be deleted by an operator until that data have been deleted from respective programs.
4. Network communications software shall manage and control multiple network communications to provide exchange of global information and execution of global programs.
5. Operator interface software shall include day-to-day operator transaction processing, alarm and report handling, operator privilege level and data segregation control, custom programming, and online data modification capability.
6. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.

B. Operator Interface Software:

1. Minimize operator training through use of English language pronouncing and English language point identification.
2. Minimize use of a typewriter-style keyboard through use of a pointing device similar to a mouse.
3. Operator sign-off shall be a manual operation or, if no keyboard or mouse activity takes place, an automatic sign-off.
4. Automatic sign-off period shall be programmable from one to 60 minutes in one-minute increments on a per operator basis.
5. Operator sign-on and sign-off activity shall be recorded and sent to printer.
6. Security Access:
 - a. Operator access to DDC system shall be under password control.
 - b. An alphanumeric password shall be field assignable to each operator.
 - c. Operators shall be able to access DDC system by entry of proper password.
 - d. Operator password shall be same regardless of which computer or other interface means is used.
 - e. Additions or changes made to passwords shall be updated automatically.
 - f. Each operator shall be assigned an access level to restrict access to data and functions the operator is capable of performing.
 - g. Software shall have at least five access levels.
 - h. Each menu item shall be assigned an access level so that a one-for-one correspondence between operator assigned access level(s) and menu item access level(s) is required to gain access to menu item.
 - i. Display menu items to operator with those capable of access highlighted. Menu and operator access level assignments shall be online programmable and under password control.
7. Operators shall be able to perform commands from the CEMOC including, but not limited to, the following:
 - a. Start or stop selected equipment.
 - b. Adjust set points.
 - c. Add, modify, and delete time programming.
 - d. Enable and disable process execution.
 - e. Lock and unlock alarm reporting for each point.
 - f. Enable and disable totalization for each point.
 - g. Enable and disable trending for each point.
 - h. Override control loop set points.

- i. Enter temporary override schedules.
 - j. Define holiday schedules.
 - k. Change time and date.
 - l. Enter and modify analog alarm limits.
 - m. Enter and modify analog warning limits.
 - n. View limits.
 - o. Enable and disable demand limiting.
 - p. Enable and disable duty cycle.
 - q. Display logic programming for each control sequence.
 - 8. Reporting:
 - a. Generated automatically and manually.
 - b. Sent to displays, printers and disk files.
 - c. Types of Reporting:
 - 1) General listing of points.
 - 2) List points currently in alarm.
 - 3) List of off-line points.
 - 4) List points currently in override status.
 - 5) List of disabled points.
 - 6) List points currently locked out.
 - 7) List of items defined in a "Follow-Up" file.
 - 8) List weekly schedules.
 - 9) List holiday programming.
 - 10) List of limits and deadbands.
 - 9. Summaries: For specific points, for a logical point group, for an operator selected group(s), or for entire system without restriction due to hardware configuration.
- C. Graphic Interface Software:
- 1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
 - 2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface shall use a pointing device with pull-down or penetrating menus, color, and animation to facilitate operator understanding of system.
 - 3. Include at least 10 levels of graphic penetration with the hierarchy operator assignable.
 - 4. Descriptors for graphics, points, alarms, and such shall be modified through operator's workstation under password control.
 - 5. Graphic displays shall be online user definable and modifiable using the hardware and software provided.
 - 6. Data to be displayed within a graphic shall be assignable regardless of physical hardware address, communication, or point type.
 - 7. Graphics are to be online programmable and under password control.
 - 8. Points may be assignable to multiple graphics where necessary to facilitate operator understanding of system operation.
 - 9. Graphics shall also contain software points.
 - 10. Penetration within a graphic hierarchy shall display each graphic name as graphics are selected to facilitate operator understanding.

11. Back-trace feature shall permit operator to move upward in the hierarchy using a pointing device. Back trace shall show all previous penetration levels. Include operator with option of showing each graphic full screen size with back trace as horizontal header or by showing a "stack" of graphics, each with a back trace.
12. Display operator accessed data on the monitor.
13. Operator shall select further penetration using pointing device to click on a site, building, floor, area, equipment, and so on. Defined and linked graphic below that selection shall then be displayed.
14. Include operator with means to directly access graphics without going through penetration path.
15. Dynamic data shall be assignable to graphics.
16. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
17. Use color, rotation, or other highly visible means, to denote status and alarm states. Color shall be variable for each class of points, as chosen by operator.
18. For operators with appropriate privilege, points shall be commanded directly from display using pointing device.
 - a. For an analog command point such as set point, current conditions and limits shall be displayed and operator can position new set point using pointing device.
 - b. For a digital command point such as valve position, valve shall show its current state such as open or closed and operator could select alternative position using pointing device.
 - c. Keyboard equivalent shall be available for those operators with that preference.
19. Operator shall be able to split or resize viewing screen into quadrants to show one graphic on one quadrant of screen and other graphics or spreadsheet, bar chart, word processing, curve plot and other information on other quadrants on screen. This feature shall allow real-time monitoring of one part of system while displaying other parts of system or data to better facilitate overall system operation.
20. Help Features:
 - a. On-line context-sensitive help utility to facilitate operator training and understanding.
 - b. Bridge to further explanation of selected keywords. Document shall contain text and graphics to clarify system operation.
 - 1) If help feature does not have ability to bridge on keywords for more information, a complete set of user manuals shall be provided in an indexed word-processing program, which shall run concurrently with operating system software.
 - c. Available for Every Menu Item:
 - 1) Index items for each system menu item.
21. Graphic generation software shall allow operator to add, modify, or delete system graphic displays.
 - a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols.
 - b. Graphic development package shall use a pointing device in conjunction with a drawing program to allow operator to perform the following:
 - 1) Define background screens.
 - 2) Define connecting lines and curves.

- 3) Locate, orient and size descriptive text.
- 4) Define and display colors for all elements.
- 5) Establish correlation between symbols or text and associated system points or other displays.

D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:

1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:
 - a. Room layouts with room identification and name.
 - b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
 - c. Location and identification of each hardware point being controlled or monitored by DDC system.
3. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.
4. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, gateways, and operator workstation.

E. Customizing Software:

1. Software to modify and tailor DDC system to specific and unique requirements of equipment installed, to programs implemented and to staffing and operational practices planned.
2. Online modification of DDC system configuration, program parameters, and database using menu selection and keyboard entry of data into preformatted display templates.
3. As a minimum, include the following modification capability:
 - a. Operator assignment shall include designation of operator passwords, access levels, point segregation and auto sign-off.
 - b. Peripheral assignment capability shall include assignment of segregation groups and operators to consoles and printers, designation of backup workstations and printers, designation of workstation header points and enabling and disabling of print-out of operator changes.
 - c. System configuration and diagnostic capability shall include communications and peripheral port assignments, DDC controller assignments to network, DDC controller enable and disable, assignment of command trace to points and application programs and initiation of diagnostics.
 - d. System text addition and change capability shall include English or native language descriptors for points, segregation groups and access levels and action messages for alarms, run time and trouble condition.
 - e. Time and schedule change capability shall include time and date set, time and occupancy schedules, exception and holiday schedules and daylight savings time schedules.
 - f. Point related change capability shall include the following:
 - 1) System and point enable and disable.
 - 2) Run-time enable and disable.

- 3) Assignment of points to segregation groups, calibration tables, lockout, and run time and to a fixed I/O value.
- 4) Assignment of alarm and warning limits.

g. Application program change capability shall include the following:

- 1) Enable and disable of software programs.
- 2) Programming changes.
- 3) Assignment of comfort limits, global points, time and event initiators, time and event schedules and enable and disable time and event programs.

Software shall allow operator to add points, or groups of points, to DDC system and to link them to energy optimization and management programs. Additions and modifications shall be online programmable using operator workstation, downloaded to other network devices, and entered into their databases. After verification of point additions and associated program operation, database shall be uploaded and recorded on hard drive and disk for archived record.

4. Include high-level language programming software capability for implementation of custom DDC programs. Software shall include a compiler, linker, and up- and down-load capability.
5. Include a library of DDC algorithms, intrinsic control operators, arithmetic, logic and relational operators for implementation of control sequences. Also include, as a minimum, the following:
 - a. Proportional control (P).
 - b. Proportional plus integral (PI).
 - c. Proportional plus integral plus derivative (PID).
 - d. Adaptive and intelligent self-learning control.
 - 1) Algorithm shall monitor loop response to output corrections and adjust loop response characteristics according to time constant changes imposed.
 - 2) Algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of system dynamics so that on system shut down and restart, learning process starts from where it left off.
6. Fully implemented intrinsic control operators including sequence, reversing, ratio, time delay, time of day, highest select AO, lowest select AO, analog controlled digital output, analog control AO, and digitally controlled AO.
7. Logic operators such as "And," "Or," "Not," and others that are part of a standard set available with a high-level language.
8. Arithmetic operators such as "Add," "Subtract," "Multiply," "Divide," and others that are part of a standard set available with a high-level language.
9. Relational operators such as "Equal To," "Not Equal To," "Less Than," "Greater Than," and others that are part of a standard set available with a high-level language.

F. Alarm Handling Software:

1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers, gateways, and other network devices.
2. Include first in, first out handling of alarms according to alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.
3. Alarm handling shall be active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
4. Alarms display shall include the following:

- a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
 - b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
 - c. Discrete per point alarm action message, such as "Call Maintenance Dept. Ext-5561."
 - d. Include extended message capability to allow assignment and printing of extended action messages. Capability shall be operator programmable and assignable on a per point basis.
5. Alarms shall be directed to appropriate operator workstation, printer, and individual operators by privilege level and segregation assignments.
6. Send e-mail alarm messages to designated operators.
7. Send e-mail, page, text, and voice messages to designated operators for critical alarms.
8. Alarms shall be categorized and processed by class.
 - a. Class 1:
 - 1) Associated with fire, security and other extremely critical equipment monitoring functions; have alarm, trouble, return to normal, and acknowledge conditions printed and displayed.
 - 2) Unacknowledged alarms to be placed in unacknowledged alarm buffer.
 - 3) All conditions shall cause an audible sound and shall require individual acknowledgment to silence audible sound.
 - b. Class 2:
 - 1) Critical, but not life-safety related, and processed same as Class 1 alarms, except do not require individual acknowledgment.
 - 2) Acknowledgement may be through a multiple alarm acknowledgment.
 - c. Class 3:
 - 1) General alarms; printed, displayed, and placed in unacknowledged alarm buffer queues.
 - 2) Each new alarm received shall cause an audible sound. Audible sound shall be silenced by "acknowledging" alarm or by pressing a "silence" key.
 - 3) Acknowledgement of queued alarms shall be either on an individual basis or through a multiple alarm acknowledgement.
 - 4) Alarms returning to normal condition shall be printed and not cause an audible sound or require acknowledgment.
 - d. Class 4:
 - 1) Routine maintenance or other types of warning alarms.
 - 2) Alarms to be printed only, with no display, no audible sound and no acknowledgment required.
9. Include an unacknowledged alarm indicator on display to alert operator that there are unacknowledged alarms in system. Operator shall be able to acknowledge alarms on an individual basis or through a multiple alarm acknowledge key, depending on alarm class.
10. To ensure that no alarm records are lost, it shall be possible to assign a backup printer to accept alarms in case of failure of primary printer.

G. Reports and Logs:

1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
 2. Each report shall be definable as to data content, format, interval, and date.
 3. Report data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on workstation for historical reporting.
 4. Operator shall be able to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
 5. Reports and logs shall be stored on workstation hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
 6. Reports and logs shall be readily printed and set to be printed either on operator command or at a specific time each day.
- H. Standard Reports: Standard DDC system reports shall be provided, and operator shall be able to customize reports later.
1. All I/O: With current status and values.
 2. Alarm: All current alarms, except those in alarm lockout.
 3. Disabled I/O: All I/O points that are disabled.
 4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
 5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
 6. Logs:
 - a. Alarm history.
 - b. System messages.
 - c. System events.
 - d. Trends.
- I. Custom Reports: Operator shall be able to easily define any system data into a daily, weekly, monthly, or annual report. Reports shall be time and date stamped and shall contain a report title.
- J. HVAC Equipment Reports: Prepare Project-specific reports.
1. The BMS shall tabulate overall energy consumption each energy meter. Data shall be reported in a user friendly format.
 - a. Consolidated Electrical Demand Report

Metered Systems	Present kW Demand	Month	
		Peak Demand	Day/Time
Electric Meter	-	-	-

- b. Daily, monthly, and annual electrical energy usage by meter shall be summarized in the following tabular reports:

Consolidated Daily Electrical Energy Usage Report

Current Month (Date)	Total (kWH)
1	-
2	-
3	-
4	-
5	-
6	-
7	-
8	-
9	-
10	-
11	-
12	-
13	-
14	-
15	-
16	-
17	-
18	-
19	-
20	-

K. Energy Reports: Prepare Project-specific daily, weekly, monthly and annual energy reports.

1. Prepare report for each energy utility, indicating the following:

- Time period being reported with beginning and end date, and time indicated.
- Consumption in units of measure commonly used to report specific utility consumption over time.
- Cost per utility unit.
- Utility cost per unit area.
- Convert all utilities to a common energy consumption unit of measure and report for each utility.

- f. Consumption per unit area using common unit of measure.

L. Standard Trends:

1. Trend all I/O point present values, set points, and other parameters indicated for trending. The systems controlled and/or monitored shall include, but are not limited to the following:
 - a. Heating and Cooling Systems
 - b. Emergency Generator
 - c. Domestic Hot Water
 - d. Lighting
 - e. Fire Alarm
 - f. Security
 - g. Electrical Power
 - h. Domestic Water
 - i. Makeup Water
2. Trends shall be associated into groups, and a trend report shall be set up for each group.
3. Trends shall be stored within DDC controller and uploaded to hard drives automatically.
4. Preset trend intervals for each I/O point after review with Owner.
5. Trend intervals shall be operator selectable from 10 seconds up to 60 minutes. Minimum number of consecutive trend values stored at one time shall be 100 per variable.
6. When drive storage memory is full, most recent data shall overwrite oldest data.
7. Archived and real-time trend data shall be available for viewing numerically and graphically by operators.

M. Custom Trends: Operator shall be able to define a custom trend log for any I/O point in DDC system.

1. Each trend shall include interval, start time, and stop time.
2. Data shall be sampled and stored on DDC controller, within storage limits of DDC controller, and then uploaded to archive on workstation hard drives.
3. Data shall be retrievable for use in spreadsheets and standard database programs.

N. Programming Software:

1. Include programming software to execute sequences of operation indicated.
2. Include programming routines in simple and easy to follow logic with detailed text comments describing what the logic does and how it corresponds to sequence of operation.
3. Programing software shall be as follows:
 - a. Graphic Based: Programming shall use a library of function blocks made from preprogrammed code designed for DDC control systems.
 - 1) Function blocks shall be assembled with interconnection lines that represent to control sequence in a flowchart.
 - 2) Programming tools shall be viewable in real time to show present values and logical results of each function block.
 - b. Menu Based: Programming shall be done by entering parameters, definitions, conditions, requirements, and constraints.

4. Include means for detecting programming errors and testing software control strategies with a simulation tool before implementing in actual control. Simulation tool may be inherent with programming software or as a separate product.

O. Database Management Software:

1. Where a separate SQL database is used for information storage, DDC system shall include database management software that separates database monitoring and managing functions by supporting multiple separate windows.
2. Database secure access shall be accomplished using standard SQL authentication including ability to access data for use outside of DDC system applications.
3. Database management function shall include summarized information on trend, alarm, event, and audit for the following database management actions:
 - a. Backup.
 - b. Purge.
 - c. Restore.
4. Database management software shall support the following:
 - a. Statistics: Display database server information and trend, alarm, event, and audit information on database.
 - b. Maintenance: Include method of purging records from trend, alarm, event, and audit databases by supporting separate screens for creating a backup before purging, selecting database, and allowing for retention of a selected number of day's data.
 - c. Backup: Include means to create a database backup file and select a storage location.
 - d. Restore: Include a restricted means of restoring a database by requiring operator to have proper security level.
5. Database management software shall include information of current database activity, including the following:
 - a. Ready.
 - b. Purging record from a database.
 - c. Action failed.
 - d. Refreshing statistics.
 - e. Restoring database.
 - f. Shrinking a database.
 - g. Backing up a database.
 - h. Resetting Internet information services.
 - i. Starting network device manager.
 - j. Shutting down the network device manager.
 - k. Action successful.
6. Database management software monitoring functions shall continuously read database information once operator has logged on.
7. Include operator notification through on-screen pop-up display and e-mail message when database value has exceeded a warning or alarm limit.
8. Monitoring settings window shall have the following sections:
 - a. Allow operator to set and review scan intervals and start times.

- b. E-mail: Allow operator to create and review e-mail and phone text messages to be delivered when a warning or an alarm is generated.
 - c. Warning: Allow operator to define warning limit parameters, set reminder frequency and link e-mail message.
 - d. Alarm: Allow operator to define alarm limit parameters, set reminder frequency and link e-mail message.
 - e. Database Login: Protect system from unauthorized database manipulation by creating a read access and a write access for each of trend, alarm, event and audit databases as well as operator proper security access to restore a database.
- 9. Monitoring settings taskbar shall include the following informational icons:
 - a. Normal: Indicates by color and size, or other easily identifiable means that all databases are within their limits.
 - b. Warning: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their warning limit.
 - c. Alarm: Indicates by color and size, or other easily identifiable means that one or more databases have exceeded their alarm limit.
- P. Real-Time Control Dashboard:
 - 1. Provide in chart form a display indicating all mechanical system equipment and components.
 - 2. The data listed for each system component should include that which is listed under "display and trending" in the "Sequence of Operations for HVAC Controls and Building Interface" section.
 - 3. This display shall be in Real-Time and indicate all systems components simultaneously.
 - 4. Separate page of all abbreviations used on the dashboard screens shall be created and available for review.
 - 5. The points available in the charts of the dashboard shall correspond with the points displayed on the graphic screens. The same abbreviation and/or symbol shall be used for the same variable on the dashboard and on the graphic screens.
 - 6. All data displayed on the dashboard shall be able to be saved and printed in the Excel spreadsheet format.
 - 7. The sample of a dashboard is included below. The exact format and content of the dashboard shall be coordinated with the Client/User.
 - 8. Provide current weather data and system optimization and anticipation based on historical weather data.

SAMPLE ONLY

Ambient Conditions

temp

63.6 °F

RH

62 %

MAJOR SYSTEMS - DASHBOARD MONITOR

Chilled Water Plant

CT-1

CT-2

Condenser Water Loop Pumps

Condenser Water Loop

CH-1

CH-2

Chilled Water Loop Pumps

Chilled Water Loop

Hot Water Plant

B-1

B-2

Hot Water Loop Pumps

Hot Water Loop

SAMPLE ONLY

Ambient Conditions

temp 63.6 °F
RH 62 %

MAJOR SYSTEMS - DASHBOARD MONITOR - Continued

Air Distribution Systems

AHU-1		AHU-2		RTU-1		RTU-2	
Run Command	On	Run Command	On	Run Command	On	Run Command	On
Alarm	On	Alarm	On	Alarm 1	On	Alarm 1	On
SA Flow	8,530 CFM	SA Flow	6,450 CFM	Alarm 2	On	Alarm 2	On
OA Flow	1,830 CFM	OA Flow	1,380 CFM	SA Flow	12,200 CFM	SA Flow	9,630 CFM
SA Temp	55.2 °F	SA Temp	55.2 °F	OA Flow	2,500 CFM	OA Flow	2,010 CFM
SA Stpt	55.0 °F	SA Stpt	55.0 °F	SA Temp	60.1 °F	SA Temp	55.8 °F
CHW Valve	52 %	CHW Valve	25 %	SA Stpt	63.0 °F	SA Stpt	55.0 °F
HW Valve	0 %	HW Valve	0 %	SA RH	85.0 %	SA RH	83.0 %
SA Static Press	2.3 "wc	SA Static Press	1.5 "wc	DX Capacity	18 %	DX Capacity	75 %
SA Static Pres Stpt	2.3 "wc	SA Static Pres Stpt	1.5 "wc	HW Valve	0 %	HW Valve	0 %
VFD Speed	50 %	VFD Speed	56 %	SA Static Press	1.5 "wc	SA Static Press	1.5 "wc
Humidity Stpt	40 % rh	Humidity Stpt	35 % rh	SA Static Pres Stpt	1.5 "wc	SA Static Pres Stpt	1.5 "wc
Humidity	50.8 % rh	Humidity	57.4 % rh	VFD Speed	45.6 Hz	VFD Speed	52.8 Hz
Humidifier Cmd	0 %	Humidifier Cmd	0 %	Filter P.D.	0.75 in.WG	Filter P.D.	0.75 in.WG
Filter P.D.	0.75 in.WG	Filter P.D.	0.75 in.WG				

Exhaust Systems

EF-1		EF-2	
Alarm	Off	Alarm	Off
S/S	On	S/S	On
Status	On	Status	On
Damper Status	Open	Damper Status	Open
EA Static Press	-0.92 "wc	EA Static Pres	0.92 "wc
EA Static Pres Stpt	-1.00 "wc	EA Static Pres Stpt	-1.00 "wc

SAMPLE ONLY

INDIVIDUAL SYSTEMS - DASHBOARD MONITOR

RTU-3																					
HW System Supply Temp		167.1 °F																			
CHW System Supply Temp		47.5 °F																			
Run	General	General	SA Flow	OA Flow	SA	Temp	SA	Temp Stpt	RH	SA	DX	HW	HW	HW Coil	SA	SA	VFD	Heat	Cool		
Command	Alarm1	Alarm 2	CFM	CFM	CFM	°F	°F	°F	%	%	Capacity	Valve	Valve	Lvg Temp	Static Press	Static Press	Stpt	Speed	Requests		
On	On	On	13,100	2,820	57.9	55.0	55.0	83%	55.0	83%	55.0%	0%	0%	127.0 °F	1.5 "wc	1.5 "wc	49.2 Hz	2	21		
Area	Unit ID	Zone	Temp °F	Clg SP °F	Htg SP °F	Damp Pos	SA Temp °F	Airflow CFM	Airflow SP CFM	HW Valve											
361	vav 2-1	72.0	70.0	67.0	24.1%	56.6	244	250	0%	0%											
368	vav 2-2	67.5	78.0	65.0	27.8%	55.7	88	85	0%	0%											
321	vav 2-3	74.0	75.8	69.8	36.8%	57.1	88	80	0%	0%											
315	vav 2-4	67.9	84.0	66.0	33.8%	56.5	125	115	0%	0%											
325-328	vav 2-5	73.1	75.0	68.0	28.1%	57.0	162	150	0%	0%											
340-343	vav 2-6	74.8	80.0	75.0	30.7%	80.0	174	170	14%	0%											
344-347	vav 2-7	72.1	76.0	66.0	43.7%	56.9	183	170	0%	0%											
348-352	vav 2-8	71.5	78.0	66.0	43.8%	56.5	306	280	0%	0%											
370	vav 2-9	71.7	75.7	69.7	28.9%	56.6	359	350	0%	0%											
363,366,380	vav 2-10	72.3	73.0	68.0	37.0%	56.5	87	80	0%	0%											
381-383	vav 2-11	72.0	75.0	65.0	43.1%	55.6	122	115	0%	0%											
386,387	vav 2-12	71.5	71.7	68.7	29.6%	55.2	278	265	0%	0%											
377,378	vav 2-13	71.4	68.0	63.0	74.9%	55.7	549	550	0%	0%											
312	vav 2-14	68.4	70.0	67.0	46.0%	57.6	87	85	0%	0%											
358A	vav 2-15	68.0	70.0	67.0	31.3%	56.7	93	85	0%	0%											
367	vav 2-16	68.0	70.0	67.0	36.3%	56.2	94	85	0%	0%											
322	flu 2-1	73.5	76.9	65.9	35.2%	69.0	109	100	0%	0%	Off										
323	flu 2-2	71.3	70.0	65.0	55.2%	62.5	400	400	0%	0%	On	861									
320	flu 2-3	68.1	87.0	69.0	29.2%	81.5	551	525	100%	0%	On	528									
319	flu 2-4	71.0	68.0	63.0	73.5%	57.5	1,800	1,800	0%	0%	Off										
332,333	flu 2-5	71.7	68.0	63.0	85.8%	56.5	1,192	1,200	0%	0%	Off										

SAMPLE ONLY

INDIVIDUAL SYSTEMS - DASHBOARD MONITOR - Continued

HW System Supply Temp		167.1 °F																	
CHW System Supply Temp		47.5 °F																	
RTU-3																			
Run	General	General	SA Flow	OA Flow	SA	Temp	SA	Temp Stp	RH	SA	DX	HW	Valve	Lvg Temp	Static Press	Static Press Stp	SA	VFD	Cool
Command	Alarm1	Alarm 2	CFM	CFM	CFM	°F	°F	°F	%	%	%	%	%	°F	"wc	"wc		Speed	Requests
On	On	On	13,100	2,820	57.9	55.0	83%	55.0	0%	127.0	49.2	0%	0%	0%	0%	0%	0%	49.2 Hz	21
Area		Unit ID	Zone	Clg SP	Htg SP	Damp	SA Temp	Airflow	CFM	SP CFM	Valve	CO2							
			Temp °F	°F	°F	Pos	°F	CFM	CFM	Status	PPM								
334,335		flu 2-6	71.4	72.0	62.0	39.7%	56.2	220	220	Off		516							
336		flu 2-7	75.5	70.0	65.0	47.3%	57.2	400	400	Off		512							
354		flu 2-8	70.1	70.0	68.0	98.8%	67.4	1,088	1,100	On		506							
357		flu 2-9	73.0	73.4	63.4	32.0%	64.4	351	360	On		512							
369		flu 2-10	70.7	75.0	65.0	38.0%	64.4	148	145	On		506							
371,372		flu 2-11	72.5	70.5	65.5	57.7%	64.4	1,198	1,200	Off		503							
306		flu 2-12	70.5	79.0	64.0	39.6%	64.4	79	75	On		536							
305		flu 2-13	71.9	72.0	63.0	28.3%	64.4	162	163	On		536							
373,374		flu 2-14	73.3	70.0	65.0	88.9%	64.4	1,005	1,000	Off									
375,376		flu 2-15	72.3	68.0	63.0	100.0%	64.4	1,099	1,200	Off									
370		flu 2-16	72.8	75.0	72.0	26.5%	64.4	152	145	Off									

2.11 ASHRAE 135 GATEWAYS

- A. Include BACnet communication ports, whenever available as an equipment OEM standard option, for integration via a single communication cable. BACnet-controlled plant equipment includes, but is not limited to, boilers, air handling units and variable-speed drives.
- B. Include gateways to connect BACnet to legacy systems, existing non-BACnet devices, and existing non-BACnet DDC-controlled equipment, only when specifically requested and approved by Owner.
- C. Include with each gateway an interoperability schedule showing each point or event on legacy side that BACnet "client" will read, and each parameter that BACnet network will write to. Describe this interoperability of BACnet services, or BIBBs, defined in ASHRAE 135, Annex K.
- D. Gateway Minimum Requirements:
 - 1. Read and view all readable object properties on non-BACnet network to BACnet network and vice versa where applicable.
 - 2. Write to all writeable object properties on non-BACnet network from BACnet network and vice versa where applicable.
 - 3. Include single-pass (only one protocol to BACnet without intermediary protocols) translation from non-BACnet protocol to BACnet and vice versa.
 - 4. Comply with requirements of Data Sharing Read Property, Data Sharing Write Property, Device Management Dynamic Device Binding-B, and Device Management Communication Control BIBBs according to ASHRAE 135.
 - 5. Hardware, software, software licenses, and configuration tools for operator-to-gateway communications.
 - 6. Backup programming and parameters on CD media and the ability to modify, download, backup, and restore gateway configuration.

2.12 DDC CONTROLLERS

- A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.
- B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.
- C. DDC controllers shall use a multitasking, multiuser, real-time digital control microprocessor with a distributed network database and intelligence.
- D. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.
- E. Environment Requirements:
 - 1. Controller hardware shall be suitable for the anticipated ambient conditions.
- F. Maintenance and Support: Include the following features to facilitate maintenance and support:
 - 1. Mount microprocessor components on circuit cards for ease of removal and replacement.
 - 2. Means to quickly and easily disconnect controller from network.
 - 3. Means to quickly and easily access connect to field test equipment.

4. Visual indication that controller electric power is on, of communication fault or trouble, and that controller is receiving and sending signals to network.

G. Input and Output Point Interface:

1. Hardwired input and output points shall connect to network, programmable application and application-specific controllers.
2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.

2.13 NETWORK CONTROLLERS

A. General Network Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.
2. System shall consist of one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
3. Controller shall have enough memory to support its operating system, database, and programming requirements.
4. Data shall be shared between networked controllers and other network devices.
5. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
6. Controllers that perform scheduling shall have a real-time clock.
7. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
8. Controllers shall be fully programmable.

B. Communication:

1. Network controllers shall communicate with other devices on DDC system network.
2. Network controller also shall perform routing if connected to a network of programmable application and application-specific controllers.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation.

D. Serviceability:

1. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
2. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.14 PROGRAMMABLE APPLICATION CONTROLLERS

A. General Programmable Application Controller Requirements:

1. Include adequate number of controllers to achieve performance indicated.

2. Controller shall have enough memory to support its operating system, database, and programming requirements.
3. Data shall be shared between networked controllers and other network devices.
4. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
5. Controllers that perform scheduling shall have a real-time clock.
6. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
7. Controllers shall be fully programmable.

B. Communication:

1. Programmable application controllers shall communicate with other devices on network.

C. Operator Interface:

1. Controller shall be equipped with a service communications port for connection to a portable operator's workstation.

D. Serviceability:

1. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
2. Controller shall maintain BIOS and programming information in event of a power loss for at least 72 hours.

2.15 APPLICATION-SPECIFIC CONTROLLERS

- A. Description: Microprocessor-based controllers, which through hardware or firmware design are dedicated to control a specific piece of equipment. Controllers are not fully user-programmable but are configurable and customizable for operation of equipment they are designed to control.

1. Capable of standalone operation and shall continue to include control functions without being connected to network.
2. Data shall be shared between networked controllers and other network devices.

- B. Communication: Application-specific controllers shall communicate with other application-specific controller and devices on network, and to programmable application and network controllers.

- C. Operator Interface: Controller shall be equipped with a service communications port for connection to a portable operator's workstation.

D. Serviceability:

1. Wiring and cable connections shall be made to field-removable, modular terminal strips or to a termination card connected by a ribbon cable.
2. Controller shall use nonvolatile memory and maintain all BIOS and programming information in event of power loss.

2.16 CONTROLLER SOFTWARE

A. General Controller Software Requirements:

1. Software applications shall reside and operate in controllers. Editing of applications shall occur at operator workstations.
2. Control functions shall be executed within controllers using DDC algorithms.
3. Controllers shall be configured to use stored default values to ensure fail-safe operation. Default values shall be used when there is a failure of a connected input instrument or loss of communication of a global point value.

B. Security:

1. Operator access shall be secured using individual security passwords and usernames.
2. Passwords shall restrict operator to points, applications, and system functions as assigned by system manager.
3. Operator log-on and log-off attempts shall be recorded.
4. System shall protect itself from unauthorized use by automatically logging off after last keystroke. The delay time shall be operator-definable.

C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule shall consist of the following:

1. Weekly Schedule:

- a. Include separate schedules for each day of week.
- b. Each schedule should include the capability for start, stop, optimal start, optimal stop, and night economizer.
- c. Each schedule may consist of up to 10 events.
- d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.

2. Exception Schedules:

- a. Include ability for operator to designate any day of the year as an exception schedule.
- b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.

3. Holiday Schedules:

- a. Include capability for operator to define up to 99 special or holiday schedules.
- b. Schedules may be placed on scheduling calendar and will be repeated each year.
- c. Operator shall be able to define length of each holiday period.

D. System Coordination:

1. Include standard application for proper coordination of equipment.
2. Application shall include operator with a method of grouping together equipment based on function and location.
3. Group may then be used for scheduling and other applications.

E. Alarm Reporting:

1. Operator shall be able to determine action to be taken in event of an alarm.
 2. Alarms shall be routed to appropriate operator workstations based on time and other conditions.
 3. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.
- F. Remote Communication:
1. System shall have ability to dial out in the event of an alarm.
- G. Maintenance Management: System shall monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.
- H. Sequencing: Include application software based on sequences of operation indicated to properly sequence chillers, boilers, and other applicable HVAC equipment.
- I. Control Loops:
1. Support any of the following control loops, as applicable to control required:
 - a. Two-position (on/off, open/close, slow/fast) control.
 - b. Proportional control.
 - c. Proportional plus integral (PI) control.
 - d. Proportional plus integral plus derivative (PID) control.
 - 1) Include PID algorithms with direct or reverse action and anti-windup.
 - 2) Algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs.
 - 3) Controlled variable, set point, and PID gains shall be operator-selectable.
 - e. Adaptive (automatic tuning).
- J. Staggered Start: Application shall prevent all controlled equipment from simultaneously restarting after a power outage. Order which equipment (or groups of equipment) is started, along with the time delay between starts, shall be operator-selectable.
- K. Energy Calculations:
1. Include software to allow instantaneous power or flow rates to be accumulated and converted to energy usage data.
 2. Include an algorithm that calculates a sliding-window average (rolling average). Algorithm shall be flexible to allow window intervals to be operator specified (such as 15, 30, or 60 minutes).
 3. Include an algorithm that calculates a fixed-window average. A digital input signal shall define start of window period (such as signal from utility meter) to synchronize fixed-window average with that used by utility.
- L. Run-Time Totalization:
1. Include software to totalize run-times for applicable points.
 2. A high run-time alarm shall be assigned, if required, by operator.

2.17 ELECTRICAL POWER DEVICES

A. DC Power Supply:

1. Plug-in style suitable for mating with a standard eight-pin octal socket. Include the power supply with a mating mounting socket.
2. Enclose circuitry in a housing.
3. Include both line and load regulation to ensure a stable output. To protect both the power supply and the load, power supply shall have an automatic current limiting circuit.
4. Performance:
 - a. Output voltage nominally 25-V dc within 5 percent.
 - b. Output current up to 100 mA.
 - c. Input voltage nominally 120-V ac, 60 Hz.
 - d. Load regulation within 0.5 percent from zero- to 100-mA load.
 - e. Line regulation within 0.5 percent at a 100-mA load for a 10 percent line change.
 - f. Stability within 0.1 percent of rated volts for 24 hours after a 20-minute warmup.

2.18 UNINTERRUPTABLE POWER SUPPLY (UPS) UNITS

- ### A. UPS units shall provide continuous, regulated output power without using their batteries during brown-out, surge, and spike conditions.
- ### B. Load served shall not exceed 75 percent of UPS rated capacity, including power factor of connected loads.
1. Larger-capacity units shall be provided for systems with larger connected loads.
 2. UPS shall provide 15 minutes of battery power.
- ### C. Performance:
1. Input Voltage: Single phase, 120- or 230-V ac, compatible with field power source.
 2. Load Power Factor Range (Crest Factor): 0.65 to 1.0.
 3. Output Voltage: 101- to 132-V ac, while input voltage varies between 89 and 152-V ac.
 4. On Battery Output Voltage: Sine wave.
 5. Inverter overload capacity shall be minimum 150 percent for 30 seconds.
 6. Recharge time shall be a maximum of six hours to 90 percent capacity after full discharge to cutoff.
 7. Transfer Time: 6 ms.
 8. Surge Voltage Withstand Capacity: IEEE C62.41, Categories A and B; 6 kV/200 and 500 A; 100-kHz ringwave.
- ### D. UPS shall be automatic during fault or overload conditions.
- ### E. Unit with integral line-interactive, power condition topology to eliminate all power contaminants.
- ### F. Include front panel with power switch and visual indication of power, battery, fault and temperature.
- ### G. Unit shall include an audible alarm of faults and front panel silence feature.
- ### H. Unit with four NEMA WD 1, NEMA WD 6 Configuration 5-15R receptacles.

- I. UPS shall include dry contacts (digital output points) for low battery condition and battery-on (primary utility power failure).
- J. Batteries shall be sealed lead-acid type and be maintenance free. Battery replacement shall be front accessible by user without dropping load.
- K. Include tower models installed in ventilated cabinets to the particular installation location.

2.19 PIPING AND TUBING

A. Pneumatic, and Pressure Instrument Signal Air, Tubing and Piping:

- 1. Products in this paragraph are intended for use with the following:
 - a. Signal air between pressure instruments, such as sensors, switches, transmitters, controllers, and accessories.
- 2. Copper Tubing:
 - a. Seamless phosphor deoxidized copper, soft annealed or drawn tempered, with chemical and physical properties according to ASTM B 75.
 - b. Performance, dimensions, weight, and tolerance according to ASTM B 280.
 - c. Diameter, as required by application, not less than nominal 0.25 inch.
 - d. Wall thickness, as required by the application, but not less than 0.030 inch.
- 3. Copper Tubing Connectors and Fittings:
- 4. Polyethylene Tubing:
 - a. Fire-resistant black virgin polyethylene according to ASTM D 1248, Type 1, Class C and Grade 5.
 - b. Tubing shall comply with stress crack test according to ASTM D 1693.
 - c. Diameter, as required by application, of not less than nominal 0.25 inch.
- 5. Polyethylene Tubing Connectors and Fittings:
 - a. Brass, barbed fittings.
 - b. Brass, compression type.

2.20 ACCESSORIES

A. Pneumatic Pressure Gages:

- 1. Pressure gages shall a 1.5-inch-diameter face for pressures up through 30 psig and 2.5-inch-diameter face for greater pressures.
- 2. Include separate gages for branch pressure and main pressure lines.
- 3. White dial face with black printing.
- 4. Include 1-psig increment for scale ranges through 30 psig and 2-psig increment for larger ranges.
- 5. Accuracy: Within 1 percent of full-scale range.

B. Pressure Electric Switches:

- 1. Diaphragm-operated snap acting switch.
- 2. Set point adjustable from 3 to 20 psig.

3. Differential adjustable from 2 to 6 psig.
 4. Rated for resistance loads at 120-V ac.
 5. Body and switch housing shall be metal.
- C. Damper Blade Limit Switches:
1. Sense positive open and/or closed position of the damper blades.
 2. NEMA 250, Type 13, oil-tight construction.
 3. Arrange for the mounting application.
 4. Additional waterproof enclosure when required by its environment.
 5. Arrange to prevent "over-center" operation.
- D. I/P and E/P Transducers:
1. Commercial Grade:
 - a. The transducer shall convert an AO signal to a stepped pneumatic signal. Unless otherwise required by the operating sequence, use a 3- to 15-psig pneumatic signal for pneumatic actuation.
 - b. Construct the entire assembly so that shock and vibration will neither harm the transducer nor affect its accuracy.
 - c. Transducer shall have auto/manual output switch, manual output control and an output pressure gage.
 - d. Accuracy: Within 1.0 percent of the output span.
 - e. Linearity: Within 0.5 percent of the output span.
 - f. Output Capacity: Not less than 550 scim at 15 psig.
 - g. Transducer shall have separate zero and span calibration adjustments.
 - h. The transducer shall withstand up to 40 psig of supply pressure without damage.
 - i. For use on only modulating pneumatic outputs that are associated with terminal units, including fan-coil units, VAV units, and unit heaters.
- E. E/P Switch:
1. Construct the body of cast aluminum or brass; three pipe body (common, normally open, and normally closed).
 2. Internal construction of steel, copper or brass.
 3. Air Connections: Barb.
 4. Rating of 30 psig when installed in systems below 25 psig and of 150 psig when installed in systems above 25 psig.
 5. Include coil transient suppression.
- F. Instrument Enclosures:
1. Include instrument enclosure for secondary protection to comply with requirements indicated in "Performance Requirements" Article.
 2. NRTL listed and labeled to UL 50.
 3. Sized to include at least 25 percent spare area on subpanel.
 4. Instrument(s) mounted within enclosure on internal subpanel(s).
 5. Enclosure face with engraved, laminated phenolic nameplate for each instrument within enclosure.
 6. Enclosures housing pneumatic instruments shall include main pressure gage and a branch pressure gage for each pneumatic device, installed inside.
 7. Enclosures housing multiple instruments shall route tubing and wiring within enclosure in a raceway having a continuous removable cover.

8. Enclosures larger than 12 inches shall have a hinged full-size face cover.
9. Equip enclosure with lock and common key.

G. Manual Valves:

1. Needle Type:
 - a. PTFE packing.
 - b. Construct of brass for use with copper and polyethylene tubing and of stainless steel for use with stainless-steel tubing.
 - c. Aluminum T-bar handle.
 - d. Include tubing connections.
2. Ball Type:
 - a. Body: Bronze ASTM B 62 or ASTM B 61.
 - b. Ball: Type 316 stainless steel.
 - c. Stem: Type 316 stainless steel.
 - d. Seats: Reinforced PTFE.
 - e. Packing Ring: Reinforced PTFE.
 - f. Lever: Stainless steel with a vinyl grip.
 - g. 600 WOG.
 - h. Threaded end connections.

2.21 IDENTIFICATION

A. Control Equipment, Instruments, and Control Devices:

1. Engraved tag bearing unique identification.
 - a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.
2. Tag shall consist of white lettering on black background.
3. Tag shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded black with contrasting white center exposed by engraving through outer layer.
4. Tag shall be fastened with drive pins.
5. Instruments, control devices and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

B. Valve Tags:

1. Brass tags and brass chains attached to valve.
2. Tags shall be at least 1.5 inches in diameter.
3. Include tag with unique valve identification indicating control influence such as flow, level, pressure, or temperature; followed by location of valve, and followed by three-digit sequential number. For example: TV-1.001.
4. Valves with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require an additional tag.

C. Raceway and Boxes:

1. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
2. Paint cover plates on junction boxes and conduit same color as the tape banding for conduits. After painting, label cover plate "HVAC Controls," using an engraved phenolic tag.
3. For raceways housing pneumatic tubing, add a phenolic tag labeled "HVAC Instrument Air Tubing."
4. For raceways housing air signal tubing, add a phenolic tag labeled "HVAC Air Signal Tubing."

D. Equipment Warning Labels:

1. Acrylic label with pressure-sensitive adhesive back and peel-off protective jacket.
2. Lettering size shall be at least 14-point type with white lettering on red background.
3. Warning label shall read "CAUTION-Equipment operated under remote automatic control and may start or stop at any time without warning. Switch electric power disconnecting means to OFF position before servicing."
4. Lettering shall be enclosed in a white line border. Edge of label shall extend at least 0.25 inch beyond white border.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 1. Verify compatibility with and suitability of substrates.
- B. Examine roughing-in for products to verify actual locations of connections before installation.
 1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
 2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- C. Examine walls, floors, roofs, and ceilings for suitable conditions where product will be installed.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

- A. Communication Interface to Equipment with Integral Controls:
 1. DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.
 2. Equipment to Be Connected:
 - a. VRF Systems.
 - b. Variable-frequency controllers specified in Section 262923 "Variable-Frequency Motor Controllers."

- c. VAV and fan powered boxes.

B. Communication Interface to Other Building Systems:

1. DDC system shall have a communication interface with systems having a communication interface.
2. Systems to Be Connected:
 - a. Electrical power metering.
 - b. Lighting Control System.
 - c. Elevator sump pumps
 - d. Domestic hot water heaters.
 - e. Domestic hot water circulation pumps.
 - f. Kitchen freezer and cooler.
 - g. Culinary freezer and cooler

3.3 CONTROL DEVICES FOR INSTALLATION BY INSTALLERS

- A. Deliver selected control devices, specified in indicated HVAC instrumentation and control device Sections, to identified equipment and systems manufacturers for factory installation and to identified installers for field installation.
- B. Deliver all duct mounted devices to the duct fabricator and Installer for installation in ductwork. Include installation instructions to Installer and supervise installation for compliance with requirements.
- C. Deliver all pipe mounted devices to plumbing and HVAC piping installers for installation in piping. Include installation instructions to Installer and supervise installation for compliance with requirements.

3.4 GENERAL INSTALLATION REQUIREMENTS

- A. Install products to satisfy more stringent of all requirements indicated, including manufacturer's recommendations.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Support products, tubing, piping wiring and raceways. Brace products to prevent lateral movement and sway or a break in attachment.
- D. If codes and referenced standards are more stringent than requirements indicated, comply with requirements in codes and referenced standards.
- E. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- F. Firestop penetrations made in fire-rated assemblies.
- G. Seal penetrations made in acoustically rated assemblies.
- H. Fastening Hardware:
 1. Stillson wrenches, pliers, and other tools that damage surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening fasteners.

2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 3. Lubricate threads of bolts, nuts and screws with graphite and oil before assembly.
- I. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.
- J. If a field-mounted device or piece of equipment requires 120 V ac service and is mounted at a different location from 120 V ac power source provided under Electrical: Division 26, provide extensions to power wiring, including conduit, junction boxes, and other hardware, in accordance with Electrical: Division 26. This requirement shall also apply to devices powered by 24 V ac.
- K. Damper actuators that are placed in plenums shall be mounted on damper frames. Damper actuators shall not be installed in ducts or fresh-air intakes.
- L. Thermostats, temperature sensors, humidistats and humidity sensors located on exterior walls shall be mounted on back-insulated blocks.
- M. Provide labor for coordination and preparation during testing and balancing of systems as performed under Testing and Balancing of Mechanical Systems: Division 1 and Preparation for Testing and Balancing of Mechanical Systems: Division 23. 48 hours of labor shall be included to support testing and balancing of mechanical systems. This time shall be in addition to Work indicated.
- N. Provide required cooperation and coordination with Electrical: Division 26 such that all power and ground wiring is provided in accordance with DDC system equipment manufacturer's written recommendations. DDC system supplier/installer shall make final electrical connections to DDC system equipment.
- J. Keep cable runs as short as possible, allowing extra length for connecting to terminal boards. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners or through penetrations. Provide strain relief loops in wiring harness between sub-panel terminal points and panel-mounted components.
- K. Temperature:
1. RTDs: RTDs may be used in ducts, piping or spaces. When RTD is installed in pipes, it shall be installed in a thermowell. Coordinate thermowell locations with Mechanical Installer. When installed in airstreams or spaces, RTDs shall be rigidly supported. RTDs used for space-temperature sensing shall include a housing suitable for wall mounting. RTDs used for outside-air sensing shall have an instrument shelter to minimize solar effects, and shall be mounted to isolate building thermal effects. All RTD assemblies shall be readily accessible and installed in such a manner as to allow for easy replacement. Sensors located outdoors shall be NEMA 4 rated.
 2. Temperature Switches: Install temperature switches as specified for RTDs. Temperature switches shall be verified by calibration. Switch contact ratings shall be selected so as to meet expected load.
- L. Pressure:
1. Pressure Switches: Pressure switches (all types) installed on liquid lines shall have siphons. All pressure switches shall have valves for isolation and venting, and taps for

- calibration. Coordinate requirements with Mechanical Installer. Pressure switches shall be adjusted to proper setpoint, and shall be verified by calibration. Pressure switches shall be mounted higher than process connection.
2. Differential-pressure switches shall have three-way manifold valves. Switch contact ratings and duty shall be selected for expected load.
 3. Provide all necessary pressure fittings (in addition to that indicated on Mechanical Drawings) for installation.
 4. Size (for specific range) and adjust each differential-pressure switch used for fan and pump status to ensure reliable monitoring and eliminate false status feedback.

- M. Provide weathershield/enclosure to protect actuators and linkages from outside conditions of snow and ice build-up.
- N. Provide NEMA 4 enclosures for electric or electronic devices mounted in outdoor locations.
- O. Keep cable runs as short as possible, allowing extra length for connecting to terminal boards. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners or through penetrations. Provide strain relief loops in wiring harness between sub-panel terminal points and panel-mounted components.

3.5 OPERATOR WORKSTATION INSTALLATION

A. Desktop Operator Workstations Installation:

1. Install software on workstation and verify software functions properly
2. Develop Project-specific graphics, trends, reports, logs and historical database.
3. Power workstation through a dedicated UPS unit. Locate UPS adjacent to workstation.

B. Color Graphics Application:

1. Use system schematics indicated as starting point to create graphics.
2. Develop Project-specific library of symbols for representing system equipment and products.
3. Incorporate digital images of Project-completed installation into graphics where beneficial to enhance effect.
4. Submit sketch of graphic layout with description of all text for each graphic for Owner's and Engineer's review before creating graphic using graphics software.
5. Seek Owner input in graphics development once using graphics software.
6. Final editing shall be done on-site with Owner's and Engineer's review and feedback.
7. Refine graphics as necessary for Owner acceptance.
8. On receiving Owner acceptance, print a hard copy for inclusion in operation and maintenance manual. Prepare a scanned copy PDF file of each graphic and include with softcopy of DDC system operation and maintenance manual.

3.6 GATEWAY INSTALLATION

- A. Install gateways if required for DDC system communication interface requirements indicated.
- B. Test gateways to verify that communication interfaces function properly.

3.7 CONTROLLER INSTALLATION

- A. Install controllers in enclosures to comply with indicated requirements.

- B. Connect controllers to field power supply.
- C. Install controller with latest version of applicable software and configure to execute requirements indicated.
- D. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.
- E. Installation of Network Controllers:
 - 1. Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
 - 2. Install controllers in a protected location that is easily accessible by operators.
- F. Installation of Programmable Application Controllers:
 - 1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
 - 2. Install controllers in a protected location that is easily accessible by operators.
- G. Application-Specific Controllers:
 - 1. Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
 - 2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.8 ELECTRIC POWER CONNECTIONS

- A. Connect electrical power to DDC system products requiring electrical power connections.
- B. All power connections to control panels shall be connected to standby power to allow HVAC system operation during a power disruption. Coordinate with Division 26.

3.9 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements in Division 26 for identification products and installation.
- B. Install engraved phenolic nameplate with unique identification on face for each of the following:
 - 1. Gateway.
 - 2. DDC controller.
 - 3. Enclosure.
 - 4. Electrical power device.
 - 5. UPS unit.
- C. Install engraved phenolic nameplate with unique instrument identification on face of each instrument connected to a DDC controller.
- D. Warning Labels:
 - 1. Shall be permanently attached to equipment that can be automatically started by DDC control system.

2. Shall be located in highly visible location near power service entry points.

3.10 NETWORK INSTALLATION

- A. Install copper cable or fiber-optic cable when connecting between network devices.

3.11 NETWORK NAMING AND NUMBERING

- A. Coordinate with Owner and provide unique naming and addressing for networks and devices.

3.12 PIPING AND TUBING INSTALLATION

- A. Above-Grade Pneumatic and Air Signal Piping and Tubing Installation:

1. Material Application:

- a. Install copper tubing for sizes up through NPS 1 and install galvanized-steel pipe for larger sizes, except as follows:
 - 1) Tubing Exposed to View: Polyethylene tubing installed in raceways may be used in lieu of copper tubing where exposed to view.
- b. Install drawn-temper copper tubing, except within 36 inches of device terminations tubing shall be annealed-tempered copper tubing.
- c. Install compression fittings to connect copper tubing to instruments, control devices, and accessories.
- d. Install barbed or compression fittings to connect polyethylene tubing to instruments, control devices, and accessories.

2. Routing:

- a. Do not expose tubing in finished spaces, such as spaces with ceilings; occupied spaces, offices, and conference rooms, unless expressly approved in writing by Engineer. Tubing may be exposed in areas without ceilings.
- b. Where tubing is installed in finished occupied spaces, install the tubing in surface metal raceway with appropriate fittings only where not feasible to conceal in wall, above ceiling or behind architectural enclosures or covers.
- c. Install piping and tubing plumb and parallel to and at right angles with building construction.
- d. Install multiple runs of tubing or piping in equally spaced parallel lines.
- e. Piping and tubing shall not interfere with access to valves, equipment, duct and equipment access doors, or obstruct personnel access and passageways of any kind.
- f. Coordinate with other trades before installation to prevent proposed piping and tubing from interfering with pipe, duct, terminal equipment, light fixtures, conduit and cable tray space. If changes to Shop Drawings are necessary due to field coordination, document changes on record Drawings.
- g. Install vibration loops in copper tubing when connecting to instrument and actuators that vibrate.

3. Support:

- a. According to MSS SP-69, Table 3, except support spacing shall not exceed 60 inches.

- b. Support copper tubing with copper hangers, clips, and tube trays.
 - c. Do not use tape for support or dielectric isolation.
 - d. Install supports at each change in direction and at each branch take off.
 - e. Attached supports to building structure independent of work of other trades. Support from ducts, pipes, cable trays, and conduits is prohibited.
 - f. Attached support from building structure with threaded rods, structural shapes, or channel strut.
 - g. Install and brace supports to carry static load plus a safety margin, which will allow tubing to be serviced.
 - h. Brace supports to prevent lateral movement.
 - i. Paint steel support members that are not galvanized or zinc coated.
 - j. Support polyethylene tubing same as copper tubing.
4. Do not attach piping and tubing to equipment that may be removed frequently for maintenance or that may impart vibration and expansion from temperature change.
5. Joining and Makeup:
 - a. Where joining and mating dissimilar metals where galvanic action could occur, install dielectric isolation.
 - b. Install a dirt leg with an isolation valve and threaded plug at each main air, connection to a panel, pneumatic pilot positioner and PRV station.
 - c. Make threaded joints for connecting to instrument equipment with connectors with a compression tubing connector on one end and threaded connection on other end.
 - d. Make tubing bends with a tube-bending tool. Hard bends, wrinkled or flattened bends are unacceptable.
 - e. Install tube fittings according to manufacturer's written instructions.
 - f. Do not make tubing connections to a fitting before completing makeup of the connection.
 - g. Align tubing with the fitting. Avoid springing tube into position, as this may result in excessive stress on both tubing and fitting with possible resulting leaks.
 - h. Do not install fittings close to a bend. A length of straight tubing, not deformed by bending, is required for a proper connection.
 - i. Check tubing for correct diameter and wall thickness.
 - j. Tube ends shall be cut square and deburred. Exercise care during cutting to keep tubing round.
 - k. Thread pipe on a threading machine. Ream inner edges of pipe ends, file and grind to remove burrs.
 - l. Wrap pipe threads of fittings on pneumatic lines with a single wrap of PTFE tape.
 - m. Protect piping and tubing from entrance of foreign matter.
6. Conduit in which nonmetallic tubing is installed shall not exceed 50 percent fill. Support conduit according to NFPA 70 unless otherwise indicated.

B. Identify piping and tubing as follows:

1. Every 50 feet of straight run.
2. At least once for each branch within 36 inches of main tee.
3. At each change in direction.
4. Within 36 inches of each ceiling, floor, roof, and wall penetration.
5. Where exposed to and where concealed from view, including above ceiling plenums, shafts, and chases.
6. At each valve.

7. Mark each instrument tube connection with a number-coded identification. Each unique tube shall have same unique number at instrument connection and termination at opposite end of tube.

3.13 CONTROL WIRE, CABLE, AND RACEWAYS INSTALLATION

A. Wiring Method:

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways, boxes, and conduits specified in Division 26.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Field Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

D. Conduit Installation:

1. Install conduit expansion joints where conduit runs exceed 200 feet, and conduit crosses building expansion joints.
2. Coordinate conduit routing with other trades to avoid conflicts with ducts, pipes and equipment and service clearance.
3. Maintain at least 3-inch separation where conduits run axially above or below ducts and pipes.
4. Limit above-grade conduit runs to 100 feet without pull or junction box.
5. Do not install raceways or electrical items on any "explosion-relief" walls, or rotating equipment.
6. Do not fasten conduits onto the bottom side of a metal deck roof.
7. Flexible conduit is permitted only where flexibility and vibration control is required.
8. Limit flexible conduit to 3 feet long.
9. Conduit shall be continuous from outlet to outlet, from outlet to enclosures, pull and junction boxes, and shall be secured to boxes in such manner that each system shall be electrically continuous throughout.
10. Direct bury conduits underground or install in concrete-encased duct bank where indicated.
 - a. Use rigid, nonmetallic, Schedule 80 PVC.
 - b. Provide a burial depth according to NFPA 70, but not less than 24 inches.
11. Secure threaded conduit entering an instrument enclosure, cabinet, box, and trough, with a locknut on outside and inside, such that conduit system is electrically continuous throughout. Provide a metal bushing on inside with insulated throats. Locknuts shall be the type designed to bite into the metal or, on inside of enclosure, shall have a grounding wedge lug under locknut.
12. Conduit box-type connectors for conduit entering enclosures shall have an insulated throat.
13. Connect conduit entering enclosures in wet locations with box-type connectors or with watertight sealing locknuts or other fittings.
14. Offset conduits where entering surface-mounted equipment.
15. Seal conduit runs used by sealing fittings to prevent the circulation of air for the following:
 - a. Conduit extending from interior to exterior of building.

- b. Conduit extending into pressurized duct and equipment.
- c. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.

E. Wire and Cable Installation:

1. Cables serving a common system may be grouped in a common raceway. Install control wiring and cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
2. Install cables with protective sheathing that is waterproof and capable of withstanding continuous temperatures of 90 deg C with no measurable effect on physical and electrical properties of cable.
 - a. Provide shielding to prevent interference and distortion from adjacent cables and equipment.
3. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
5. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire shall have a unique tag.
6. Provide strain relief.
7. Terminate wiring in a junction box.
 - a. Clamp cable over jacket in junction box.
 - b. Individual conductors in the stripped section of the cable shall be slack between the clamping point and terminal block.
8. Terminate field wiring and cable not directly connected to instruments and control devices having integral wiring terminals using terminal blocks.
9. Install signal transmission components according to IEEE C2, REA Form 511a, NFPA 70, and as indicated.
10. Keep runs short. Allow extra length for connecting to terminal boards. Do not bend flexible coaxial cables in a radius less than 10 times the cable OD. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
11. Ground wire shall be copper and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.
12. Wire and cable shall be continuous from terminal to terminal without splices.
13. Use insulated spade lugs for wire and cable connection to screw terminals.
14. Use shielded cable to transmitters.
15. Use shielded cable to temperature sensors.
16. Perform continuity and meager testing on wire and cable after installation.
17. Do not install bruised, kinked, scored, deformed, or abraded wire and cable. Remove and discard wire and cable if damaged during installation and replace it with new cable.
18. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
19. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
20. Protection from Electro-Magnetic Interference (EMI): Provide installation free of (EMI). As a minimum, comply with the following requirements:

- a. Comply with BICSI TDMM and TIA 569-C for separating unshielded cable from potential EMI sources, including electrical power lines and equipment.
- b. Separation between open cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
- c. Separation between cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
- d. Separation between cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
- e. Separation between Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inches.
- f. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.14 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

- 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Testing:

- 1. Perform preinstallation, in-progress, and final tests, supplemented by additional tests, as necessary.
- 2. Preinstallation Cable Verification: Verify integrity and serviceability for new cable lengths before installation. This assurance may be provided by using vendor verification documents, testing, or other methods. As a minimum, furnish evidence of verification for cable attenuation and bandwidth parameters.
- 3. In-Progress Testing: Perform standard tests for correct pair identification and termination during installation to ensure proper installation and cable placement. Perform tests in addition to those specified if there is any reason to question condition of material furnished and installed. Testing accomplished is to be documented by agency conducting tests. Submit test results for Project record.
- 4. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by DDC system manufacturer.

Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.

5. Test Equipment: Use a fiber-optic time domain reflectometer for testing of length and optical connectivity.
6. Test Results: Record test results and submit copy of test results for Project record.

3.15 DDC SYSTEM I/O CHECKOUT PROCEDURES

- A. Check installed products before continuity tests, leak tests and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
- D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material and support.
- E. For pneumatic products, verify that air supply for each product is properly installed.
- F. Control Damper Checkout:
 1. Verify that control dampers are installed correctly for flow direction.
 2. Verify that proper blade alignment, either parallel or opposed, has been provided.
 3. Verify that damper frame attachment is properly secured and sealed.
 4. Verify that damper actuator and linkage attachment is secure.
 5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
 6. Verify that damper blade travel is unobstructed.
- G. Control Valve Checkout:
 1. Verify that control valves are installed correctly for flow direction.
 2. Verify that valve body attachment is properly secured and sealed.
 3. Verify that valve actuator and linkage attachment is secure.
 4. Verify that actuator wiring is complete, enclosed and connected to correct power source.
 5. Verify that valve ball, disc or plug travel is unobstructed.
 6. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.
- H. Instrument Checkout:
 1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
 2. Verify that attachment is properly secured and sealed.
 3. Verify that conduit connections are properly secured and sealed.
 4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
 5. Inspect instrument tag against approved submittal.
 6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
 7. For flow instruments, verify that recommended upstream and downstream distances have been maintained.

8. For temperature instruments:
 - a. Verify sensing element type and proper material.
 - b. Verify length and insertion.

3.16 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:

- A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
- B. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
- C. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
- D. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.
- E. Provide diagnostic and test equipment for calibration and adjustment.
- F. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. An installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
- G. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
- H. If after calibration indicated performance cannot be achieved, replace out-of-tolerance instruments.
- I. Comply with field testing requirements and procedures indicated by ASHRAE's Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.
- J. Analog Signals:
 1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
 2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
 3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.
- K. Digital Signals:
 1. Check digital signals using a jumper wire.
 2. Check digital signals using an ohmmeter to test for contact making or breaking.
- L. Control Dampers:
 1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.

2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

M. Control Valves:

1. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
2. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed and 100 percent open at proper air pressures.
3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
4. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

N. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

O. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

P. Switches: Calibrate switches to make or break contact at set points indicated.

Q. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.17 DDC SYSTEM CONTROLLER CHECKOUT

A. Verify power supply.

1. Verify voltage, phase and hertz.
2. Verify that protection from power surges is installed and functioning.
3. Verify that ground fault protection is installed.
4. If applicable, verify if connected to UPS unit.
5. If applicable, verify if connected to a backup power source.
6. If applicable, verify that power conditioning units, transient voltage suppression and high-frequency noise filter units are installed.

B. Verify that wire and cabling is properly secured to terminals and labeled with unique identification.

C. Verify that spare I/O capacity is provided.

3.18 DDC CONTROLLER I/O CONTROL LOOP TESTS

A. Testing:

1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
2. Test every I/O point throughout its full operating range.
3. Test every control loop to verify operation is stable and accurate.
4. Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
5. Test and adjust every control loop for proper operation according to sequence of operation.
6. Test software and hardware interlocks for proper operation. Correct deficiencies.
7. Operate each analog point at the following:
 - a. Upper quarter of range.
 - b. Lower quarter of range.
 - c. At midpoint of range.
8. Exercise each binary point.
9. For every I/O point in DDC system, read and record each value at operator workstation, at DDC controller and at field instrument simultaneously. Value displayed at operator workstation, at DDC controller and at field instrument shall match.
10. Prepare and submit a report documenting results for each I/O point in DDC system and include in each I/O point a description of corrective measures and adjustments made to achieve desired results.

3.19 FINAL REVIEW

- A. Submit written request to Engineer Commissioning Agent, and Construction Manager when DDC system is ready for final review. Written request shall state the following:
 1. DDC system has been thoroughly inspected for compliance with contract documents and found to be in full compliance.
 2. DDC system has been calibrated, adjusted, and tested and found to comply with requirements of operational stability, accuracy, speed, and other performance requirements indicated.
 3. DDC system monitoring and control of HVAC systems results in operation according to sequences of operation indicated.
 4. DDC system is complete and ready for final review.
- B. Review by Engineer, Commissioning Agent and Construction Manager shall be made after receipt of written request. A field report shall be issued to document observations and deficiencies.
- C. Take prompt action to remedy deficiencies indicated in field report and submit a second written request when all deficiencies have been corrected. Repeat process until no deficiencies are reported.
- D. Should more than two reviews be required, DDC system manufacturer and Installer shall compensate entity performing review for total costs, labor, and expenses, associated with third and subsequent reviews. Estimated cost of each review shall be submitted and approved by DDC system manufacturer and Installer before making the review.
- E. Prepare and submit closeout submittals when no deficiencies are reported.

- F. A part of DDC system final review shall include a demonstration to parties participating in final review.

3.20 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions.

3.21 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for one year.
- B. Provide ten software licenses with the system.
- C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within one year from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

3.22 DEMONSTRATION

- A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.
 - 1. Provide not less than five days of on-site training total.
 - 2. Training shall be six, four-hour sessions, professionally video recorded.
 - 3. Stagger training over multiple training classes to accommodate Owner's requirements. All training shall occur before end of warranty period.

END OF SECTION

SECTION 230993.11

SEQUENCE OF OPERATIONS FOR HVAC DDC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes control sequences for DDC for HVAC systems, subsystems, and equipment. The sequence of operation shall be met and applicable to all equipment instrumented with DDC controls. Provide all devices, wiring, instrumentation, software, programming, testing, and verification, complete in all respects to assure an effective, repeatable and adjustable system.
- B. Related Requirements:
 - 1. Section 230923 "DDC Systems for HVAC" for control equipment.
 - 2. Section 230910 "Instrumentation and Control Equipment" for instrumentation and control equipment requirements.
- C. The following sequences of operation shall be met and applicable to all equipment, instrumented with DDC controls. Provide all devices, wiring, instrumentation, software, programming, testing, and verification, complete in all respects to assure an effective, repeatable and adjustable system. The general and common characteristics are intended to be general in nature; refer to detailed sequences, plans, and specification sections for the various components.

1.3 DEFINITIONS

- A. Analog Output: Proportional output signal (zero- to 10-V dc, 4 to 20 mA).
- B. Binary Output: On/off output signal or contact closure.
- C. DDC: Direct digital control.
- D. Digital Output: Data output that must be interpreted digitally.

1.4 ACTION SUBMITTALS

- A. Product Data:
 - 1. An instrumentation list for each controlled system. Label each element of the controlled system in table format. Show, in the table element name, type of device, manufacturer, model number, and control device product data sheet number.
 - 2. A complete description of the operation of the control system, including sequences of operation. Include and reference a schematic diagram of the controlled system.
- B. Shop Drawings:

1. Riser diagrams showing control network layout, communication protocol, and wire types.
2. Schematic diagram of each controlled system. Include all control points labeled with point names shown or listed. Show the location of control elements in the system.
3. Wiring diagram for each controlled system. Show all control elements labels. Where a control element is the same as that shown on the control system schematic, label with the same name. Label all terminals.

1.5 GENERAL

- A. All material and equipment used shall be standard components, regularly manufactured and available and not custom-designed especially for this project. All systems and components, except site-specific software, shall have previously been thoroughly tested and proven in actual use prior to installation on this project. The manufacturer will furnish or supply a site-specific system based on customer requirements.
1. The system architecture shall be fully modular permitting expansion of application software, system peripherals, and field hardware.
 2. The system shall utilize a distributed processing architecture so that polling of all points is not de-pendent on a single processor.
- B. The systems controlled, and/or monitored, trended, alarmed by BMS, or interfaced with BMS include, but are not limited to, the following:
1. HVAC systems
 2. Life Safety Generators
 3. Domestic Hot Water
 4. Domestic Water Distribution
 5. Leak Detection Systems
- C. The system shall include the following:
1. Ethernet network by owner.
 2. Interface Modules for controlled and/or monitored equipment
 3. Universal Input Modules
 4. Customized Graphic Pages and software Configuration.
- D. Field mounted equipment shall include:
1. Local controllers.
 2. Thermostats and temperature sensors.
 3. Humidity sensors.
 4. Carbon Dioxide Sensors
 5. Pressure transmitters/transducers.
 6. Status devices for fans, pumps, motors, damper and valve positions, water-flow switches, current switches, etc.
 7. Air-flow meters and water-flow meters.
 8. Gas detection equipment.
 9. Occupancy sensors.
 10. Control dampers and valves.
 11. Electronic actuators for dampers and valves.
 12. Control transformers.
 13. Differential pressure (DP) switches/sensors.
 14. Refrigerant monitoring equipment.

- E. Electrical Components, Devices, and Accessories shall be listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use. Control wiring shall be electronic and fiber-optic cables. Harmonic filters shall be provided for all variable frequency drives, with dedicated and direct grounding.
- F. All HVAC systems and all components shall be controlled such as to maintain setpoints of temperature and/or humidity, pressure, flow, etc. in the occupied and specific equipment spaces and systems throughout the Facility according to occupied and un-occupied schedules. Additionally, this contractor is responsible for providing all sensors, relays, controllers, protocol interface cards, transducers, thermostats, humidistats, detectors, panels, switches, actuators, wiring (both 24V and 120V), conduit, and any and all other accessories/components, hardware, software, programming, connections, start-up, testing, training, etc. necessary for complete and operational systems as described here and elsewhere in these specifications. This contractor shall be responsible for these things either directly, or indirectly via a subcontractor. If the ATC submittal package, as submitted, repeats/reproduces the descriptions herein, it shall be interpreted to mean the BMS contractor understands and can provide the control described.
- G. Operator shall be able to perform the following functions through the browser interface: setpoint adjustment and timed override, view and configure trending, PID loop tuning, and download new control software to controllers.
- H. All setpoints shall be adjustable.
- I. All controls and instrumentation shall be calibrated.
- J. Accuracy of temperature measurements shall be +/- 0.5 deg F.
- K. Accuracy of humidity measurements shall be +/- 2% RH.
- L. Provide global sensors where applicable (e.g. outside air temperature/humidity)
- M. Provide lead-lag sequences for equal wear of the equipment.
- N. Provide automatic start-up of stand-by equipment if the duty equipment fails.
- O. System description and quantity of equipment is indicated in the preceding paragraphs.
- P. System alarms shall be categorized in two classifications, general and critical. Each alarm point classification shall be readily adjustable by the operator at the BAS interface. General alarms shall be provided with a dedicated general alarm graphic dashboard. These alarms do not require notification be sent, audible alarms or alarm messages visible in all user interface dashboard views. Critical alarms shall be provided with a dedicated critical alarm graphic dashboard. All critical alarms shall be visible in the dashboard, alarm messages shall be sent to designated personnel, visual and audible alarms shall be produced in all dashboard views and must be manually addressed by operators. Operators shall have ability to readily change alarm classifications at the BAS operator's interface.
- Q. BAS operators shall have the ability to easily add alarm notification (text message or email) to any alarm point through the BAS operator's interface. Alarm contact information shall be adjustable through the operator's interface.
- R. Alarm / Event information
 - 1. The user shall have the ability to view events throughout the system.

2. Dependent on access level, the user shall have the ability to manage the event through acknowledgements, deletions, sorting rules, and viewing short and extended messages.
 3. Direct link or hot spot shall be available to automatically navigate to the unit that sent the alarm.
 4. Alarms shall include pre-alarms and failure alarms.
- S. Configuration of Operators: system owner shall have the ability of assigning roles and privileges to users, which combined will define access levels.
- T. Execution of global commands: the system shall have the ability to execute a global parameter change.
- U. Operator shall be able to trend all points designated hereinafter

1.6 AIR HANDLING UNITS – GENERAL AND COMMON CHARACTERISTICS

- A. Air Handling Units shall be individually instrumented, within the units by the BMS Subcontractor, unless specifically noted otherwise in the following sequence of operations. The BMS Subcontractor shall provide all instrumentation within ductwork including all sensors and devices. The BMS Subcontractor shall provide all interlock wiring between the Air Handling Units and VRF Condensing Units. The BMS Subcontractor shall provide a programmable logic controller to orchestrate the internal operation of airflow management, reheat control, damper and energy recovery operation, all as specified under those sections. This controller system shall also be furnished with any and all external sensors which are to be field-mounted in ductwork (discharge air temperature and humidity for example), and wired to the controller under ATC.
- B. High static pressure switches shall be installed downstream of all supply fans, and low static pressure switches shall be installed upstream on the suction side of all return/ exhaust fans in VAV systems and all systems with isolation dampers including fire/ smoke dampers that may cause duct over pressurization.
- C. All units shall have smoke detectors furnished and wired to shut-down systems and interfaced with fire alarm system by Section 260000, installed by HVAC and wired by ATC to shut down respective units upon detection of smoke.
- D. All filter pressure drops shall be monitored and addressed for service change-out at prescribed values.
- E. Unit sequences are written for an individual unit and shall apply for each and all units of the type, singular language notwithstanding.
- F. References to "high" and "low" speeds reflect maximum and minimum VFD settings, not necessarily two-position operation. Volume derivation and control is required.
- G. Related function motorized dampers such as mixing and relief dampers, shall be individually instrumented and controlled. Mechanically interlocked dampers will not be acceptable.
- H. All units shall be set up by the ATC Subcontractor for at minimum the following modes of operation (with exceptions or specific units/systems noted):
1. Night/unoccupied setback and space monitoring.
 2. Morning/pre-occupancy warm-up/cool down, delayed outside air introduction.

3. Enthalpy-based (total heat) economizer free cooling in all modes occupied or unoccupied including mechanical cooling where appropriate and applicable.
4. Heating and cooling normal activity operation. Daily school activity.
5. Energy recovery control and VFD or damper driven defrost control as applicable.
6. Variable air volume duct pressure-based return and fan tracking control and static pressure reset of duct pressure set point at low load periods for all VAV units.
7. Safety device activation and shutdown including smoke detectors, freezestats, high, and low static pressure sensors on each fan.
8. Adjustable "dead band" lock-out (2 to 3 degrees F) between heating mode and cooling mode.

1.7 FANS, GENERAL AND COMMON CHARACTERISTICS

- A. All fans shall be instrumented to report status (on/off/alarm inconsistent status/ high amperage). Provide all current sensors, interlocks to starters (operation and safety-off) lockouts and programming of sequences to operate with ancillary equipment.
- B. All fans isolated by dampers shall be interlocked with damper end switches to enable start sequences; fans shall not start until the motorized isolation dampers are at least 80 percent open to prevent duct bursting or collapse.
- C. All fans with duct systems penetrating building weather barriers shall have motorized isolation dampers. All dampers at intermittent use fans and systems (where the damper acts primarily as a thermal barrier) shall be of the insulated sandwich blade type.
- D. Fans activated by temperature (cooling only function) are self-evident on the drawings. Provide interlocks to specific intake dampers and/or companion supply fans as indicated on plans and/or as scheduled. Status for these fans shall include room temperature monitoring, noting "high temperature" plus fan status "on/off" by amperage current transformer as an inconsistent status.
- E. Any fan indexed on/off by a local manual switch shall also have a DDC system-initiated override except small local toilet fans and cooling based fans serving specific electric rooms. All push-button interlocks (example, dishwasher, hood, or other process) shall be provided with a relay and green pilot light to indicate fan operation. Spare contacts shall also initiate and index parallel make-up air functions via terminal boxes, and dampers as indicated on the plans.
- F. Supply and return fans associated with air handling units shall be instrumented per sequences noted within air handling units as applicable. This shall include cfm measurement and tracking of supply airflow in a closed loop feedback control algorithm.
- G. General and toilet exhaust fans shall run based on time of day scheduling concurrent with and provisions for occupancy. This includes advanced operation ahead of occupancy and shall be in parallel to introduction of outside air for a given area. The intent is to balance intake with exhaust and not induce an unintended negative pressure within the building. Indexing of specific tagged fans to specific air handling units is coincidental. No direct physical interlock is intended but parallel operation via the DDC system is intended.
- H. Associated motorized isolation damper shall be proven open prior to energizing fans and shall close when fan is de-energized.

1.8 FIRE SMOKE AND SMOKE DAMPERS

- A. All supply, return, and exhaust air fire smoke dampers associated with a given air handling unit at duct shaft penetrations on all floors shall be interlocked to open whenever the respective unit is called to be in operation.
- B. Damper end switch status shall be provided for all fire smoke dampers. These dampers are normally powered open. Should a damper end switch indicate that a damper is not fully open when the respective unit is called to be in operation, an alarm shall be enunciated.
- C. Whenever the respective air handling unit is not in operation, all supply, return, and exhaust air fire smoke dampers shall be closed.

1.9 DEDICATED OUTSIDE AIR HANDLING SYSTEM (HRU-1, 2, 3, 4, and 5)

- A. General:
 - 1. Return air is drawn via the return/exhaust fan, through filters, the energy recovery wheel then discharged to atmosphere.
 - 2. The wheel will operate under most conditions based on need to preheat or precool outdoor air to minimize energy consumption. Generally, this means whenever the outdoor air temperature is either below or above conditions for wheel bypass economizer operation.
 - 3. Outside air is drawn in via the supply fan, through filters and through the energy recovery wheel, operating per requirements. Depending on requirements, the air will be pre-heated, as indexed by outdoor air temperature or building demand.
- B. Unit OFF/Disabled Mode
 - 1. Exhaust and outside air dampers shall be closed.
 - 2. Exhaust fan and supply fan shall be deenergized.
 - 3. Enthalpy wheel shall be deenergized.
 - 4. Electric pre-heat shall be deenergized.
 - 5. Wheel bypass dampers shall be closed (normally closed).
- C. Night/Unoccupied Setback Mode and Morning Warmup/Cooldown Mode
 - 1. Unit is normally "off" per Unit OFF/Disabled Mode above.
- D. Unit Start Mode
 - 1. The unit start time shall be determined by an Optimal Start program based on building temperature and outdoor temperature conditions.
 - 2. Recirculation damper shall open.
 - 3. Return air and supply air isolation dampers shall open. End switches shall signal the supply fan to start.
 - 4. Supply fan shall be energized at low speed and shall gradually increase to maintain supply duct static pressure set point.
 - 5. Return air temperature shall be monitored.
 - 6. If return air temperature is 67 deg. F or below, the unit hot water control valve shall be modulated open to maintain 82 deg. F discharge temperature. Upon an increase in return air temperature to 70 degrees F the hot water control valve shall close.

7. If return air temperature is 78 deg. F or above, the unit VRF system shall be enabled in cooling mode and shall modulate to maintain 60 deg. F discharge temperature. Upon a decrease in return air temperature to 75 degrees F the VRF system shall be disabled.
8. When the occupied start time begins, the enthalpy wheel shall start, and the outside air and exhaust air isolation dampers shall open.
9. Exhaust damper end switch shall signal the exhaust fan to start and the recirculation damper shall close.
10. The exhaust fan shall increase speed to maintain the exhaust air duct static pressure set point.

E. During Normal Occupied Mode Operation (Discharge Air Temperature Control):

1. Below an outdoor air dewpoint of 47 deg. F, the VRF system shall be enabled in heating mode and the DX solenoid valves and compressors shall be staged to maintain 70 deg. F discharge air temperature set point.
2. Above an outdoor air dewpoint of 47 deg. F, the VRF system shall be enabled in cooling mode and the DX solenoid valves and compressors shall be staged to maintain 70 deg. F discharge air temperature set point.
3. Temperature and humidity shall be monitored downstream of the DX coil before the hot gas reheat coil. Dewpoint temperature shall be calculated. The VRF system shall modulate to maintain a 47 deg. F dewpoint temperature.
4. Upon a decrease in air temperature to 30°F (adj.) entering the electric preheat coil, the electric preheat coil shall be modulated to maintain a low limit entering air temperature to the DX coil of 35°F (adj.).

F. VRF Condensing Unit

1. All points from VRF condensing units shall be monitored through the manufacturers central controller and BACnet interface.
2. Condensing units shall be staged on with a 15 minute interval between start times to minimize the chance of defrost occurring in both circuits at the same time.
3. When a condensing unit enters defrost, the associate DX coil isolation damper shall be closed and the HRU airflow shall be reduced to 60%. When the defrost cycle is complete the RTU shall enter its normal occupied operating mode.

G. Energy Recovery Wheel Operation

1. Economizer Wheel Bypass Mode (Applicable to normal occupied operation): Whenever outdoor air temperature is between 50 deg. F and 72 deg. F and outdoor air dewpoint is below 47 deg. F, the enthalpy wheel shall be deenergized and the wheel bypass dampers shall open. The unit VRF DX coil shall be modulated open as required to maintain the unit discharge air temperature.
2. The wheel shall be instrumented with a variable frequency drive (VFD) and a controller with pre-programmed tabular parameters based on return air relative humidity, outdoor dry-bulb temperature and leaving exhaust dry-bulb temperature. The wheel shall also be instrumented with a differential pressure sensor and transducer, set up during commissioning to reflect actual clean wheel pressure drop set point.
3. When the airside parameters are at or below the tabular data threshold for frost formation, the pressure differential sensor and output shall be enabled. When differential air pressure increases above the set point, the wheel VFD shall be signaled to slow down gradually until the pressure differential is normalized to set point, at which time the wheel RPM shall increase toward normal operating speed.
4. Parameters of wheel RPM, pressure drop and entering and leaving temperature and humidity parameters shall be reported to the BMS and alarmed when outside of parameters.

H. Supply Air Temperature Reset

1. The unit discharge temperature shall be reset according to outside air temperature. Discharge temperature shall be 60°F whenever the outdoor temperature is 75°F (adj.) and above and shall be reset linearly upward to 70°F upon a decrease in outdoor temperature to 40°F (adj.). The discharge air temperature set point shall remain at 70°F whenever outdoor temperature is below 40°F.

I. Air Volume/Pressure Control and Monitoring

1. Units shall be instrumented with supply duct and exhaust duct static pressure sensors as indicated on the plans (set point 1.50 inch w.g. or as otherwise noted by testing and balancing sub-subcontractor, all adjustable). This may include multiple sensors for a given system, serving disparate branches and/or exposures. The set-up shall be for "lowest pressure priority" during high demand and normal operation. Dual pressure readings may be averaged or demand is elected to the lowest pressure priority for static pressure reset purposes.
2. This static pressure set point shall be reset downward at low load periods based on the air volume needs of terminal boxes as determined by system wide polling of terminal box positions. The intent is to track and set the lowest actual static pressure set point which will meet air delivery requirements in all zones. The static pressure set point shall be reset such that at least three zones are at 90% or greater damper position.
3. Once the system has started, the duct static pressure system shall take control and terminal boxes shall modulate from their default "system off equals boxes open" position. Duct SP set point signal shall be transmitted via the DDC system to control the supply fan and return/exhaust fan variable frequency drives to maintain the respective supply or exhaust duct static pressure. Supply and return fan inlet probe type flow measuring stations with transducers shall be provided by the ATC Subcontractor to extract instantaneous supply and return CFM volume.

1.10 MULTIPLE ZONE ROOFTOP UNIT (RTU-1)

A. Unit OFF/Disabled Mode

1. Exhaust and outside air dampers shall be closed.
2. Return air damper shall be 100% open.
3. Return/exhaust fan and supply fan shall be deenergized.
4. Electric pre-heat shall be deenergized.
5. VRF heat pump units shall be deenergized and DX coil solenoid valves shall be closed.

B. Night/Unoccupied Setback Mode

1. Unit is normally "off" per Unit OFF/Disabled Mode above.
2. Space sensors shall monitor space temperature.
3. The unit shall be enabled when space temperature falls to two degrees below the space night setback temperature setpoint of 62°F (adj.), or whenever space temperature is above 80°F and space relative humidity is 60% or greater.
4. Building return air and supply air isolation dampers shall open. End switches shall signal the supply and return fans to start in 100% recirculation air mode.
5. The supply fan shall start at low speed and shall gradually be modulated maintain the duct static pressure setpoint. The return fan shall track the supply fan CFM with an offset and shall be modulated accordingly.
6. When enabled under night setback temperature conditions, the unit VRF condensing units shall modulate to provide a discharge temperature of 80°F (adj.). Once space temperature increases to the space night setback temperature setpoint of 62°F (adj.), the

VRF condensing units shall be deenergized, the supply and return fans shall be deenergized, and the isolation dampers shall close.

7. When enabled under high temperature and humidity conditions, the unit VRF condensing units shall be enabled and the DX coil shall be modulated to provide a discharge air temperature of 55°F (adj.). Once space humidity reduces below the night setback temperature setpoint of 80°F (adj.), the VRF condensing units shall be disabled, the supply and return fans shall be deenergized, and the isolation dampers shall be closed.

C. Morning Warm-up/Cool Down Mode

1. The Warmup/Cooldown Mode start time shall be determined by an Optimal Start program based on space temperature and outdoor temperature conditions.
2. The space set points shall be indexed to their "occupied" settings.
3. Return air damper shall remain 100% open. Outside air and exhaust air dampers shall remain closed.
4. Building return air and supply air isolation dampers shall open. End switches shall signal the supply fan to start.
5. The supply fan shall start at low speed and shall gradually be modulated to maintain the duct static pressure setpoint. The return fan shall be enabled and shall modulated to track the supply fan CFM with a predetermined offset.
6. Cooling and heating shall be controlled per normally occupied mode cooling and heating sequences.
7. Upon attaining of the warmup or cooldown space temperature the system supply and return fan shall continue to run in recirculation mode and the system shall otherwise remain idle with no heating or cooling.
8. At the beginning of the scheduled occupied start time the unit shall be indexed to the Normal Occupied Mode.

D. Normal Occupied Mode (Discharge Air Temperature Control)

1. Upon being indexed to the Occupied Mode from Night/Unoccupied Mode at the beginning of the scheduled occupied start time it is assumed that the state of the system is initially as described above upon completion of the warmup or cooldown cycle. The supply fan shall continue to operate to maintain the duct static pressure set point and the outside air, exhaust air, and return air dampers shall be placed into their occupied minimum outside air positions or shall be subject to override by Economizer Cooling Mode conditions below. The return fan shall track the supply fan with an offset.
2. Heating Mode: The RTU discharge temperature sensor shall monitor supply air temperature. When the supply air temperature reduces below the supply air temperature set point of 55°F (adj.) the VRF condensing units shall be enabled in the heating mode and the compressors and DX coil solenoid valves shall be modulated/staged on to maintain the discharge air temperature setpoint.
3. Cooling Mode: The RTU discharge temperature sensor shall monitor supply air temperature. When the supply air temperature increases above the supply air temperature set point of 55 °F (adj.) the VRF condensing unit shall be enabled in the cooling mode and the compressors and DX coil solenoid valves shall be modulated/staged on to maintain the discharge air temperature setpoint.
4. Upon a decrease in mixed air temperature to 30°F (adj.) entering the electric preheat coil, the electric preheat coil shall be modulated to maintain a low limit entering air temperature to the DX coil of 35°F (adj.).
5. During occupied mode the humidifier shall be enabled. The humidifier steam output shall modulate to maintain 30% RH (adjustable) as measured by the return air humidity sensor.

E. VRF Condensing Unit

1. All points from VRF condensing units shall be monitored through the manufacturers central controller and BACnet interface.
2. Condensing units shall be staged on with a 15 minute interval between start times to minimize the chance of defrost occurring in both circuits at the same time.
3. When a condensing unit enters defrost, the associate DX coil isolation damper shall be closed and the RTU/AHU airflow shall be reduced to 60%. When the defrost cycle is complete the RTU/AHU shall enter its normal occupied operating mode.

F. Air Volume/Minimum Outside Air Mode

1. Supply and return fan inlet probe type flow measuring elements with transducers shall be provided by the ATC Subcontractor to provide supply and return CFM volume. The return fan speed control shall be configured with an offset CFM signal relative to the supply fan CFM. This signal shall be derived from direct reading of supply CFM (via fan inlet probe) and execute a corresponding return fan CFM with appropriate offset to maintain a constant airflow differential between the supply and return airflow. It is intended to provide closed-loop responsive control with appropriate PID feedback, between the fans.
2. Airflow measuring elements with transducers shall be provided by the ATC Subcontractor for measurement and control of the unit minimum outside air flow. Separate automatic control dampers shall be provided for the unit outside air damper, exhaust air damper, and return air damper. When conditions for economizer cooling mode are not in effect, the minimum outside air damper shall be 100% open and the economizer outside air damper shall be closed unless noted below.
3. Where the unit minimum outside air CFM setpoint equals the return air fan CFM offset, the exhaust air damper shall remain closed, the return air damper shall be 100% open and the return fan speed shall be modulated to maintain the minimum outside air CFM setpoint. The CFM input from the return fan inlet probes shall be used for monitoring only.
4. Where the unit minimum outside air CFM setpoint exceeds the return air fan CFM offset, the exhaust air dampers shall be modulated to maintain a return air plenum positive pressure of 0.05 in. w.g., the minimum outside air damper shall remain 100% open, the return air fan CFM shall continue to track to the offset CFM setting, and the return air damper shall be modulated between 100% and 20% open to maintain the minimum outside air CFM setpoint.
5. The minimum outside air CFM setpoint shall be reset based on space carbon dioxide (CO₂) concentration. When the indoor CO₂ concentration is below 600 PPM, the outside air CFM shall be controlled to the low minimum outside air set point of 10% outside air. When the CO₂ concentration is above 600 PPM, the minimum outside air damper shall be modulated open in proportion to indoor CO₂ concentration and upon reaching 1,000 PPM shall be controlled to the scheduled normal minimum outdoor air setting. Should the space CO₂ concentration increase to 1,200 PPM, the BMS shall indicate a "High CO₂ Notification" alarm. Should the space CO₂ concentration increase to 1,600 PPM, the BMS shall indicate a "High CO₂ Warning" alarm.
6. The scheduled unit minimum outside air CFM shall not be exceeded under any circumstances.

G. Economizer Cooling Mode

1. A global outside air enthalpy sensor shall report to the BMS as a baseline reference. Enthalpy-based economizer operation is required unless specifically noted otherwise.
2. The economizer change-over point shall be established based on pre-programmed criteria and tabular data references held within non-volatile memory.
3. Return air enthalpy sensors upstream of the return fans shall monitor return air enthalpy and compare to the outside air enthalpy. Whenever the outside air enthalpy is lower than

- the return air enthalpy, or whenever the outside air enthalpy is at or below 28.5 Btu/lb. (adj.) economizer cooling operation shall be enabled.
4. Economizer cooling operation shall be locked out whenever outside air dry bulb temperature is at or above 72°F (adj.) and the unit shall be indexed to the Minimum Outside Air Mode. The dry-bulb sensor shall take control whenever the enthalpy sensor is disabled or out of calibration.
 5. When in economizer mode, the discharge air temperature shall be controlled by modulating the economizer outside air damper and the return air damper. The minimum outside air damper shall be 100% open and the exhaust air damper shall be modulated to maintain a return air plenum positive pressure of 0.05 in. w.g. As discharge air temperature increases the economizer outside air damper shall modulate towards 100% open and the return air damper shall modulate towards the closed position. The opposite shall occur upon a decrease in discharge air temperature. Whenever the economizer outside air damper is 100% open and the discharge air temperature increases above the discharge air temperature setpoint, the unit mechanical cooling stages shall be enabled to maintain the discharge air temperature setpoint
 6. Whenever the economizer outside air damper reduces to the closed position (during cold weather conditions) and the outside air flow as measured by the minimum outside air flow sensor begins the decrease below the minimum outside air setpoint, the minimum outside air control mode shall be enabled. Space heating and heating discharge air temperature control shall be enabled as required to maintain space temperature.
 7. Economizer operation shall be capable of being manually enabled or disabled via the BMS.
 8. When the outside air enthalpy set point is exceeded, the air handling units shall revert to minimum outside air mode and mechanical cooling operation.

1.11 SINGLE ZONE ROOFTOP UNIT (RTU-2)

A. Unit OFF/Disabled Mode

1. Exhaust and outside air dampers shall be closed.
2. Return air damper shall be 100% open.
3. Return/exhaust fan and supply fan shall be deenergized.
4. Electric pre-heat shall be deenergized.
5. VRF heat pump units shall be deenergized and DX coil solenoid valves shall be closed.

B. Night/Unoccupied Setback Mode

1. Unit is normally "off" per Unit OFF/Disabled Mode above.
2. Space sensors shall monitor space temperature and humidity.
3. The unit shall be enabled when space temperature falls to two degrees below the space night setback temperature setpoint of 62°F (adj.), or whenever space temperature is above 80°F and space relative humidity is 60% or greater.
4. Building return air and supply air isolation dampers shall open. End switches shall signal the supply and return fans to start in 100% recirculation air mode.
5. The supply fan shall start at low speed and shall gradually be modulated to the 70% speed setting. The return fan shall track the supply fan CFM equally and shall be modulated accordingly.
6. When enabled under night setback temperature conditions, the unit VRF condensing units shall modulate to provide a discharge temperature of 80°F (adj.). Once space temperature increases to the space night setback temperature setpoint of 62°F (adj.), the VRF condensing units shall be deenergized, the supply and return fans shall be deenergized, and the isolation dampers shall close.
7. When enabled under high temperature and humidity conditions, the unit VRF condensing units shall be enabled and the DX coil shall be modulated to provide a discharge air

temperature of 55°F (adj.). Once space humidity reduces below 60% RH, the VRF condensing units shall be disabled, the supply and return fans shall be deenergized, and the isolation dampers shall be closed.

C. Morning Warm-up/Cool Down Mode

1. The Warmup/Cooldown Mode start time shall be determined by an Optimal Start program based on space temperature and outdoor temperature conditions.
2. The space set points shall be indexed to their "occupied" settings.
3. Return air damper shall remain 100% open. Outside air and exhaust air dampers shall remain closed.
4. Building return air and supply air isolation dampers shall open. End switches shall signal the supply fan to start.
5. The supply fan shall start at low speed and shall gradually be modulated to the 70% speed setting. The return fan shall be enabled and shall modulated to track the supply fan CFM equally.
6. Return air temperature shall be monitored.
7. If return air temperature is 65°F or below, the unit VRF condensing units shall be modulated open to provide 75°F discharge temperature. Upon an increase in return air temperature to 70°F (adj.) the VRF condensing units shall be deenergized.
8. If return air temperature is 78°F or above, the unit VRF system shall be enabled in cooling mode and shall modulate to maintain 60°F discharge temperature. Upon a decrease in return air temperature to 74°F (adj.) the VRF system shall be deenergized.
9. Upon attaining of the warmup or cooldown space temperature the system supply and return fan shall continue to run in recirculation mode and the system shall otherwise remain idle with no heating or cooling.
10. At the beginning of the scheduled occupied start time the unit shall be indexed to the Normal Occupied Mode.

D. Normal Occupied Mode (Discharge Air Temperature Control)

1. Upon being indexed to the Occupied Mode from Night/Unoccupied Mode at the beginning of the scheduled occupied start time it is assumed that the state of the system is initially as described above upon completion of the warmup or cooldown cycle. The supply fan shall initially continue to operate at the 70% speed setting and the outside air, exhaust air, and return air dampers shall be placed into their occupied minimum outside air positions per Minimum Outside Air Control or shall be subject to override by Economizer Cooling Mode conditions below.
2. The space temperature shall be controlled by modulation of the unit discharge air temperature and air volume.
3. With the supply fan initially set to the 70% speed setting and upon a decrease in space temperature below the occupied heating space temperature setpoint of 70°F (adj.) the unit VRF condensing unit shall be enabled in the heating mode and the compressors and DX coil solenoid valves shall be modulated/staged on to maintain the space temperature setpoint. Upon an increase in discharge air temperature to 84°F and a continued decrease in space temperature below the space heating setpoint, the supply fan speed shall be modulated above the 70% setting towards 100% while maintaining a constant 84°F discharge air temperature to maintain the space heating setpoint.
4. With the supply fan initially set to the 70% speed setting and upon an increase in space temperature above the occupied space cooling temperature setpoint of 75°F (adj.) the unit VRF condensing unit shall be enabled in the cooling mode and the compressors and DX coil solenoid valves shall be modulated/staged on to maintain the space temperature setpoint. Upon a decrease in discharge air temperature to 55°F (adj.) and a continued increase in space temperature above the space cooling setpoint, the supply fan speed

- shall be modulated above the 70% setting towards 100% while maintaining a constant 55°F discharge air temperature to maintain the space cooling setpoint.
5. Whenever the space temperature is in the deadband range between the space heating and cooling setpoints (70°F to 75°F), the unit supply fan shall be indexed to the 50% speed setting. Upon increasing or decreasing to the space cooling or heating temperature setpoint, respectively, the supply fan shall be indexed to the 70% speed setting and the cooling or heating control shall be enabled as above.
 6. Upon a decrease in mixed air temperature to 30°F (adj.) entering the electric preheat coil, the electric preheat coil shall be modulated to maintain a low limit entering air temperature to the DX coil of 35°F (adj.).
 7. During occupied mode the humidifier shall be enabled. The humidifier steam output shall modulate to maintain 30% RH (adjustable) as measured by the return air humidity sensor.

E. VRF Condensing Unit

1. All points from VRF condensing units shall be monitored through the manufacturers central controller and BACnet interface.
2. Condensing units shall be staged on with a 15 minute interval between start times to minimize the chance of defrost occurring in both circuits at the same time.
3. When a condensing unit enters defrost, the associate DX coil isolation damper shall be closed and the RTU/AHU airflow shall be reduced to 60%. When the defrost cycle is complete the RTU/AHU shall enter its normal occupied operating mode.

F. Air Volume/Minimum Outside Air Mode

1. Supply and return fan inlet probe type flow measuring elements with transducers shall be provided by the ATC Subcontractor to provide supply and return CFM volume. The return fan speed control shall be configured with an offset CFM signal relative to the supply fan CFM. This signal shall be derived from direct reading of supply CFM (via fan inlet probe) and execute a corresponding return fan CFM with appropriate offset to maintain a constant airflow differential between the supply and return airflow. It is intended to provide closed-loop responsive control with appropriate PID feedback, between the fans.
2. Airflow measuring elements with transducers shall be provided by the ATC Subcontractor for measurement and control of the unit minimum outside air flow. Separate automatic control dampers shall be provided for the unit outside air damper, exhaust air damper, and return air damper. When conditions for economizer cooling mode are not in effect, the minimum outside air damper shall be 100% open and the economizer outside air damper shall be closed unless noted below.
3. Where the unit minimum outside air CFM setpoint equals the return air fan CFM offset, the exhaust air damper shall remain closed, the return air damper shall be 100% open and the return fan speed shall be modulated to maintain the minimum outside air CFM setpoint. The CFM input from the return fan inlet probes shall be used for monitoring only.
4. Where the unit minimum outside air CFM setpoint exceeds the return air fan CFM offset, the exhaust air dampers shall be modulated to maintain a return air plenum positive pressure of 0.05 in. w.g., the minimum outside air damper shall remain 100% open, the return air fan CFM shall continue to track to the offset CFM setting, and the return air damper shall be modulated between 100% and 20% open to maintain the minimum outside air CFM setpoint.
5. The minimum outside air CFM setpoint shall be reset based on space carbon dioxide (CO₂) concentration. When the indoor CO₂ concentration is below 600 PPM, the outside air CFM shall be controlled to the low minimum outside air set point of 10% outside air. When the CO₂ concentration is above 600 PPM, the minimum outside air damper shall be modulated open in proportion to indoor CO₂ concentration and upon reaching 1,000

PPM shall be controlled to the scheduled normal minimum outdoor air setting. Should the space CO₂ concentration increase to 1,200 PPM, the BMS shall indicate a "High CO₂ Notification" alarm. Should the space CO₂ concentration increase to 1,600 PPM, the BMS shall indicate a "High CO₂ Warning" alarm.

6. The scheduled unit minimum outside air CFM shall not be exceeded under any circumstances.

G. Economizer Cooling Mode

1. A global outside air enthalpy sensor shall report to the BMS as a baseline reference. Enthalpy-based economizer operation is required unless specifically noted otherwise.
2. The economizer change-over point shall be established based on pre-programmed criteria and tabular data references held within non-volatile memory.
3. Return air enthalpy sensors upstream of the return fans shall monitor return air enthalpy and compare to the outside air enthalpy. Whenever the outside air enthalpy is lower than the return air enthalpy, or whenever the outside air enthalpy is at or below 28.5 Btu/lb. (adj.) economizer cooling operation shall be enabled.
4. Economizer cooling operation shall be locked out whenever outside air dry bulb temperature is at or above 72°F (adj.) and the unit shall be indexed to the Minimum Outside Air Mode. The dry-bulb sensor shall take control whenever the enthalpy sensor is disabled or out of calibration.
5. When in economizer mode, the discharge air temperature shall be controlled by modulating the economizer outside air damper and the return air damper. The minimum outside air damper shall be 100% open and the exhaust air damper shall be modulated to maintain a return air plenum positive pressure of 0.05 in. w.g. As discharge air temperature increases the economizer outside air damper shall modulate towards 100% open and the return air damper shall modulate towards the closed position. The opposite shall occur upon a decrease in discharge air temperature. Whenever the economizer outside air damper is 100% open and the discharge air temperature increases above the discharge air temperature setpoint, the unit mechanical cooling stages shall be enabled to maintain the discharge air temperature setpoint.
6. Whenever the economizer outside air damper reduces to the closed position (during cold weather conditions) and the outside air flow as measured by the minimum outside air flow sensor begins the decrease below the minimum outside air setpoint, the minimum outside air control mode shall be enabled. Space heating and heating discharge air temperature control shall be enabled as required to maintain space temperature.
7. Economizer operation shall be capable of being manually enabled or disabled via the BMS.
8. When the outside air enthalpy set point is exceeded, the air handling units shall revert to minimum outside air mode and mechanical cooling operation.

1.12 SINGLE ZONE INDOOR AIR HANDLING UNIT (AHU-1, 2, 3, 4, 5, 6, AND 7)

A. Unit OFF/Disabled Mode

1. Exhaust and outside air dampers shall be closed.
2. Return air damper shall be 100% open.
3. Return/exhaust fan and supply fan shall be deenergized.
4. Electric pre-heat shall be deenergized.
5. VRF heat pump units shall be deenergized and DX coil solenoid valves shall be closed.

B. Night/Unoccupied Setback Mode

1. Unit is normally "off" per Unit OFF/Disabled Mode above.
2. Space sensors shall monitor space temperature and humidity.

3. The unit shall be enabled when space temperature falls to two degrees below the space night setback temperature setpoint of 62°F (adj.), or whenever space temperature is above 80°F and space relative humidity is 60% or greater.
4. Building return air and supply air isolation dampers shall open. End switches shall signal the supply and return fans to start in 100% recirculation air mode.
5. The supply fan shall start at low speed and shall gradually be modulated to the 70% speed setting. The return fan shall track the supply fan CFM equally and shall be modulated accordingly.
6. When enabled under night setback temperature conditions, the unit VRF condensing units shall modulate to provide a discharge temperature of 80°F (adj.). Once space temperature increases to the space night setback temperature setpoint of 62°F (adj.), the VRF condensing units shall be deenergized, the supply and return fans shall be deenergized, and the isolation dampers shall close.
7. When enabled under high temperature and humidity conditions, the unit VRF condensing units shall be enabled and the DX coil shall be modulated to provide a discharge air temperature of 55°F (adj.). Once space humidity reduces below 60% RH, the VRF condensing units shall be disabled, the supply and return fans shall be deenergized, and the isolation dampers shall be closed.

C. Morning Warm-up/Cool Down Mode

1. The Warmup/Cooldown Mode start time shall be determined by an Optimal Start program based on space temperature and outdoor temperature conditions.
2. The space set points shall be indexed to their "occupied" settings.
3. Return air damper shall remain 100% open. Outside air and exhaust air dampers shall remain closed.
4. Building return air and supply air isolation dampers shall open. End switches shall signal the supply fan to start.
5. The supply fan shall start at low speed and shall gradually be modulated to the 70% speed setting. The return fan shall be enabled and shall modulated to track the supply fan CFM equally.
6. Return air temperature shall be monitored.
7. If return air temperature is 65°F or below, the unit VRF condensing units shall be modulated open to provide 75°F discharge temperature. Upon an increase in return air temperature to 70°F (adj.) the VRF condensing units shall be deenergized.
8. If return air temperature is 78°F or above, the unit VRF system shall be enabled in cooling mode and shall modulate to maintain 60°F discharge temperature. Upon a decrease in return air temperature to 74°F (adj.) the VRF system shall be deenergized.
9. Upon attaining of the warmup or cooldown space temperature the system supply and return fan shall continue to run in recirculation mode and the system shall otherwise remain idle with no heating or cooling.
10. At the beginning of the scheduled occupied start time the unit shall be indexed to the Normal Occupied Mode.

D. Normal Occupied Mode (Discharge Air Temperature Control)

1. Upon being indexed to the Occupied Mode from Night/Unoccupied Mode at the beginning of the scheduled occupied start time it is assumed that the state of the system is initially as described above upon completion of the warmup or cooldown cycle. The supply fan shall initially continue to operate at the 70% speed setting and the outside air, exhaust air, and return air dampers shall be placed into their occupied minimum outside air positions per Minimum Outside Air Control or shall be subject to override by Economizer Cooling Mode conditions below.
2. The space temperature shall be controlled by modulation of the unit discharge air temperature and air volume.

3. With the supply fan initially set to the 70% speed setting and upon a decrease in space temperature below the occupied heating space temperature setpoint of 70°F (adj.) the unit VRF condensing unit shall be enabled in the heating mode and the compressors and DX coil solenoid valves shall be modulated/staged on to maintain the space temperature setpoint. Upon an increase in discharge air temperature to 84°F and a continued decrease in space temperature below the space heating setpoint, the supply fan speed shall be modulated above the 70% setting towards 100% while maintaining a constant 84°F discharge air temperature to maintain the space heating setpoint.
4. With the supply fan initially set to the 70% speed setting and upon an increase in space temperature above the occupied space cooling temperature setpoint of 75°F (adj.) the unit VRF condensing unit shall be enabled in the cooling mode and the compressors and DX coil solenoid valves shall be modulated/staged on to maintain the space temperature setpoint. Upon a decrease in discharge air temperature to 55°F (adj.) and a continued increase in space temperature above the space cooling setpoint, the supply fan speed shall be modulated above the 70% setting towards 100% while maintaining a constant 55°F discharge air temperature to maintain the space cooling setpoint.
5. Whenever the space temperature is in the deadband range between the space heating and cooling setpoints (70°F to 75°F), the unit supply fan shall be indexed to the 50% speed setting. Upon increasing or decreasing to the space cooling or heating temperature setpoint, respectively, the supply fan shall be indexed to the 70% speed setting and the cooling or heating control shall be enabled as above.
6. Upon a decrease in mixed air temperature to 30°F (adj.) entering the electric preheat coil, the electric preheat coil shall be modulated to maintain a low limit entering air temperature to the DX coil of 35°F (adj.).
7. During occupied mode the humidifier shall be enabled. The humidifier steam output shall modulate to maintain 30% RH (adjustable) as measured by the return air humidity sensor.

E. VRF Condensing Unit

1. All points from VRF condensing units shall be monitored through the manufacturers central controller and BACnet interface.
2. Condensing units shall be staged on with a 15 minute interval between start times to minimize the chance of defrost occurring in both circuits at the same time.
3. When a condensing unit enters defrost, the associate DX coil isolation damper shall be closed and the RTU/AHU airflow shall be reduced to 60%. When the defrost cycle is complete the RTU/AHU shall enter its normal occupied operating mode.

F. Air Volume/Minimum Outside Air Mode

1. Supply and return fan inlet probe type flow measuring elements with transducers shall be provided by the ATC Subcontractor to provide supply and return CFM volume. The return fan speed control shall be configured with an offset CFM signal relative to the supply fan CFM. This signal shall be derived from direct reading of supply CFM (via fan inlet probe) and execute a corresponding return fan CFM with appropriate offset to maintain a constant airflow differential between the supply and return airflow. It is intended to provide closed-loop responsive control with appropriate PID feedback, between the fans.
2. Airflow measuring elements with transducers shall be provided by the ATC Subcontractor for measurement and control of the unit minimum outside air flow. Separate automatic control dampers shall be provided for the unit outside air damper, exhaust air damper, and return air damper. When conditions for economizer cooling mode are not in effect, the minimum outside air damper shall be 100% open and the economizer outside air damper shall be closed unless noted below.
3. Where the unit minimum outside air CFM setpoint equals the return air fan CFM offset, the exhaust air damper shall remain closed, the return air damper shall be 100% open

- and the return fan speed shall be modulated to maintain the minimum outside air CFM setpoint. The CFM input from the return fan inlet probes shall be used for monitoring only.
4. Where the unit minimum outside air CFM setpoint exceeds the return air fan CFM offset, the exhaust air dampers shall be modulated to maintain a return air plenum positive pressure of 0.05 in. w.g., the minimum outside air damper shall remain 100% open, the return air fan CFM shall continue to track to the offset CFM setting, and the return air damper shall be modulated between 100% and 20% open to maintain the minimum outside air CFM setpoint.
 5. The minimum outside air CFM setpoint shall be reset based on space carbon dioxide (CO₂) concentration. When the indoor CO₂ concentration is below 600 PPM, the outside air CFM shall be controlled to the low minimum outside air set point of 10% outside air. When the CO₂ concentration is above 600 PPM, the minimum outside air damper shall be modulated open in proportion to indoor CO₂ concentration and upon reaching 1,000 PPM shall be controlled to the scheduled normal minimum outdoor air setting. Should the space CO₂ concentration increase to 1,200 PPM, the BMS shall indicate a "High CO₂ Notification" alarm. Should the space CO₂ concentration increase to 1,600 PPM, the BMS shall indicate a "High CO₂ Warning" alarm.
 6. The scheduled unit minimum outside air CFM shall not be exceeded under any circumstances.

G. Economizer Cooling Mode

1. A global outside air enthalpy sensor shall report to the BMS as a baseline reference. Enthalpy-based economizer operation is required unless specifically noted otherwise.
2. The economizer change-over point shall be established based on pre-programmed criteria and tabular data references held within non-volatile memory.
3. Return air enthalpy sensors upstream of the return fans shall monitor return air enthalpy and compare to the outside air enthalpy. Whenever the outside air enthalpy is lower than the return air enthalpy, or whenever the outside air enthalpy is at or below 28.5 Btu/lb. (adj.) economizer cooling operation shall be enabled.
4. Economizer cooling operation shall be locked out whenever outside air dry bulb temperature is at or above 72°F (adj.) and the unit shall be indexed to the Minimum Outside Air Mode. The dry-bulb sensor shall take control whenever the enthalpy sensor is disabled or out of calibration.
5. When in economizer mode, the discharge air temperature shall be controlled by modulating the economizer outside air damper and the return air damper. The minimum outside air damper shall be 100% open and the exhaust air damper shall be modulated to maintain a return air plenum positive pressure of 0.05 in. w.g. As discharge air temperature increases the economizer outside air damper shall modulate towards 100% open and the return air damper shall modulate towards the closed position. The opposite shall occur upon a decrease in discharge air temperature. Whenever the economizer outside air damper is 100% open and the discharge air temperature increases above the discharge air temperature setpoint, the unit mechanical cooling stages shall be enabled to maintain the discharge air temperature setpoint.
6. Whenever the economizer outside air damper reduces to the closed position (during cold weather conditions) and the outside air flow as measured by the minimum outside air flow sensor begins the decrease below the minimum outside air setpoint, the minimum outside air control mode shall be enabled. Space heating and heating discharge air temperature control shall be enabled as required to maintain space temperature.
7. Economizer operation shall be capable of being manually enabled or disabled via the BMS.
8. When the outside air enthalpy set point is exceeded, the air handling units shall revert to minimum outside air mode and mechanical cooling operation.

1.13 ENERGY RECOVERY VENTILATOR (VARIABLE VOLUME)

A. General:

1. Return air is drawn via the return/exhaust fan, through filters, the plate and frame energy recovery device then discharged to atmosphere.
2. The energy recovery device will operate under most conditions based on need to preheat or precool outdoor air to minimize energy consumption. Generally, this means whenever the outdoor air temperature is either below or above conditions for wheel bypass economizer operation.
3. Outside air is drawn in via the supply fan, through filters and through plate and frame energy recovery device, operating per requirements. Depending on requirements, the air will be heating, as indexed by discharge air temperature or building demand.

B. Unit OFF/Disabled Mode

1. Exhaust, supply and outside air dampers shall be closed.
2. Exhaust fan and supply fan shall be deenergized.
3. Electric heating shall be deenergized.

C. Night/Unoccupied Setback Mode and Morning Warmup/Cooldown Mode

1. Unit is normally "off" per Unit OFF/Disabled Mode above.

D. Normal Occupied Mode (Air Volume/Pressure Control and Monitoring):

1. At the beginning of the scheduled occupied start time, the outside air and exhaust air isolation dampers shall open.
2. The exhaust damper end switch shall signal the exhaust fan to start, and the outside air damper end switch shall signal the supply fan to start. Initially the fans shall gradually increase speed to maintain their respective air duct static pressure set point.
3. If the discharge air temperature is 55°F (adjustable) or below, the unit electric heating coil shall be enabled and shall modulate to maintain a 55°F (adjustable) discharge temperature.

E. Air Volume/Pressure Control and Monitoring

1. Units shall be instrumented with supply duct and exhaust duct static pressure sensors. Locations shall be determined in the field. Initial setpoint shall be 1.50 inch w.g. to be calibrated and adjusted by the test and balance subcontractor. System may include multiple supply duct or exhaust duct sensors serving separate main branch ducts and/or exposures, each with an independent setpoint. The set-up shall be for "lowest pressure priority" during high demand and normal operation. Multiple supply or exhaust pressure readings shall be selected to the highest pressure priority for static pressure control purposes.
2. This static pressure set point shall be reset downward during low supply air demand conditions based on the air volume needs of terminal boxes as determined by system wide polling of terminal box positions. The intent is to track and set to the lowest static pressure set point which will meet air delivery requirements in all zones. The static pressure set point shall be reset such that at least three zones are at 90% or greater damper position.
3. Once the system has started, the duct static pressure system shall take control of the supply and exhaust fan speed and terminal boxes shall modulate from their default "system off equals boxes open" position. Duct SP set point signal shall be transmitted

via the DDC system to control the supply fan and return/exhaust fan variable frequency drives to maintain the respective supply or exhaust duct static pressure. Supply and return/exhaust fan inlet probe type flow measuring stations with transducers shall be provided by the ATC Subcontractor to extract instantaneous supply and return/exhaust CFM volume.

1.14 ENERGY RECOVERY VENTILATOR (CONSTANT VOLUME)

A. General:

1. Return air is drawn via the return/exhaust fan, through filters, the plate and frame energy recovery device then discharged to atmosphere.
2. The energy recovery device will operate under most conditions based on need to preheat or precool outdoor air to minimize energy consumption. Generally, this means whenever the outdoor air temperature is either below or above conditions for wheel bypass economizer operation.
3. Outside air is drawn in via the supply fan, through filters and through plate and frame energy recovery device, operating per requirements. Depending on requirements, the air will be pre-heated, as indexed by outdoor air temperature or building demand.

B. Unit OFF/Disabled Mode

1. Exhaust, supply and outside air dampers shall be closed.
2. Exhaust fan and supply fan shall be deenergized.
3. Electric pre-heat shall be deenergized.

C. Night/Unoccupied Setback Mode and Morning Warmup/Cooldown Mode

1. Unit is normally "off" per Unit OFF/Disabled Mode above.

D. Normal Occupied Mode (Air Volume/Pressure Control and Monitoring):

1. At the beginning of the scheduled occupied start time, the outside air and exhaust air isolation dampers shall open.
2. The exhaust damper end switch shall signal the exhaust fan to start and the outside air damper end switch shall signal the supply fan to start. The fans shall gradually increase speed to maintain their airflow setpoint.
3. If the discharge air temperature is 55°F (adjustable) or below, the unit electric pre-heat coil shall be enabled and shall modulate to maintain a 55°F (adjustable) discharge temperature.

E. Air Volume Monitoring

1. Supply and exhaust duct mounted probe type flow measuring elements with transducers shall be provided by the ATC Subcontractor to provide supply and exhaust CFM volume measurement and monitoring.

1.15 AIR TERMINAL BOXES

A. General

1. Refer to Section 233600, Air Terminal Units for terminal box types, specifications, accessories and features, and delivery/installation method of terminal box controllers at the factory.

2. All air terminal boxes shall be pressure-independent, closed-loop and status reporting. By this is intended that each terminal box air damper and controller shall maintain instantaneous cfm regardless of controlling variable (space temperature, preset constant volume or indexed volume) all compensated for varying inlet duct pressures. Further, box controller shall report percentage position open or closed, and cfm delivered at any point, via the DDC system.
 3. All air terminal boxes shall be instrumented with discharge air temperature sensors. These discharge sensors shall be used to provide diagnostic information as well as actionable data such as set point control, discharge temperature limiting, over-ride and other functions as described. Discharge temperature information shall be displayed via the user interface as a dynamic graphic.
 4. The term "terminal box" or "box" for the purposes of this specification shall be construed to mean an automated air terminal of any description, be it single-duct terminal boxes, boxes with or without a coil, but including controllers, modulating damper, inlet airflow sensors, pickups, transducers, actuators, control boards and DDC interfaces, in whole or in part as the context so indicates. The term "primary air" used in conjunction with terminal boxes, denotes cooled air from air handling units.
 5. During unoccupied hours, the terminal boxes shall not close but shall remain 50 percent or greater towards the open position. The intent is to allow supply fan starting without back-pressuring, allowing the AHU static pressure control system to take control without tripping limit controls.
 6. During morning warm-up mode, the terminal box primary air controllers shall start and remain in their minimum default positions. During morning cool-down mode, the box shall be in full temperature responsive modulating control, to maximum. During night setback/unoccupied mode, boxes shall be in their minimum positions.
- B. Single-Duct Constant Volume (CV) Operation, Standard Operation
1. The terminal box shall maintain a constant minimum baseline CFM for ventilation requirements during occupied periods.
 2. Typical Applications: Corridors, and support spaces.
- C. Single-Duct Variable Volume (VV) Operation, Occupied/Unoccupied (O/U), and CO₂
1. Occupancy status for specific use rooms such as conference rooms, shall primarily be as determined by the lighting control system such as in conference room applications.
 2. The ATC Subcontractor shall intercept status signal of the room occupancy from the lighting control system via BACnet interface. This signal output shall be extracted to the DDC system to index occupied/unoccupied or active/inactive status. In addition, the occupancy mode shall secondarily be overridden as indexed by the DDC system based on time of day scheduling or manually toggled via the DDC system. After room vacancy plus a time delay (5 - 15 minutes, adjustable), normal temperature - responsive room control with minimum ventilation set point shall resume.
 3. Conference Rooms, Classrooms, and similar high-occupancy spaces served by VV boxes, shall be also instrumented with carbon dioxide (CO₂) sensors as indicated on the plans. Where multiple CO₂ sensors serve one terminal unit, the terminal unit damper position shall be controlled by the sensor with the highest CO₂ level. When these or any such space has CO₂ control, 70% of the maximum indexed airflow, shall first be established. After a 15 minute adjustable time delay a comparison of room CO₂ shall be made. If below 800 ppm, the established indexed airflow shall be overridden and the primary air damper shall modulate toward the low minimum (10% of the VAV box maximum airflow indicated in the tag for each VAV box on the HVAC plans) and if above 800 ppm, the established indexed airflow shall be overridden and the primary air damper shall modulate toward the maximum indexed airflow. CO₂ levels shall be monitored continuously after the adjustable 15 minute time delay. The VAV box primary air damper

shall modulate between the low minimum and maximum indexed airflow to maintain the space CO₂ level at or below the space CO₂ setpoint. When the space CO₂ is above the setpoint and the VAV terminal is at the indexed maximum airflow, the terminal unit shall continue at the maximum indexed airflow until the CO₂ level drops 100 PPM (adjustable) below set point. If indexed to be unoccupied or setback, the primary airflow shall continue in maximum volume until the CO₂ level is sufficiently reduced, whereupon box modulation to low minimum may occur.

4. The room exhaust air terminal shall always track the room primary air terminal unit airflow.
5. Typical Applications: Conference Rooms, Classrooms, and Spaces with larger ventilation demands for relatively short periods and which remain unoccupied or in limited use for the majority of occupied hours.

1.16 ELECTRIC CABINET AND UNIT HEATERS

- A. Electric cabinet and unit heaters shall be provided with manufacturer thermostat for field installation under this section.
- B. Spaces served by these systems shall be instrumented with temperature sensors for monitoring by the BMS, alarming temperatures 5 degrees F below the heating setpoint temperature.

1.17 VARIABLE REFRIGERANT FLOW (VRF) SYSTEMS

- A. VRF systems shall be controlled by the VRF manufacturer's controls and shall be interfaced with the BMS through a BACnet/IP interface. All heating and cooling setpoints, operating schedules, and control points shall be adjustable from the BMS. All available points shall be monitored by the BMS system and visible at the BMS head end workstation. Unit status including defrost mode shall be displayed on each VRF system graphic.
- B. Fan coil units shall run continuously during occupied hours and unit solenoid valve shall be controlled to maintain heating and cooling setpoints (70°F and 75°F, respectively).
- C. Whenever the room is unoccupied for 20 minutes, the fan speed shall be reduced to low speed and room temperature setpoints shall be reset lower for heating by 2 degrees and higher for cooling by 2 degrees. Upon reaching the reset space temperature set point, the unit fan shall be reset to normal speed to maintain space temperature. The unit shall reset to low speed upon meeting the space temperature set point.
- D. During unoccupied hours the system shall be controlled to maintain a heating night setback temperature of 62°F (adj) and a cooling high setback temperature of 85°F (adj).
- E. Units set up with condensate drain pans and pumps shall be fitted with water detectors set up to shut down the cooling process and send an alarm via the BMS. These water detectors are typical for all pumped cooling process condensate units.

1.18 SPLIT SYSTEM AC UNITS

- A. Refer to plans and schedules for split system AC units. Connected to condensing unit as indicated on the drawings. There are several units/ systems within the building.
- B. Units shall be set up and controlled per the manufacturer's installation instructions. The ATC Subcontractor shall provide all interlocking control wiring required to complete the systems. Units shall be set up and tested for operation with HVAC installation personnel and ATC personnel present, to verify operation in all modes including winter low ambient operation.

- C. Spaces served by these systems shall be instrumented with temperature sensors for monitoring by the BMS, alarming temperatures out of range. The rooms operate on a 24/7 basis and may not be occupied.
- D. Systems shall be set up with current transformers for advanced alarming of inconsistent status, ahead of a room high temperature condition.
- E. Units set up with condensate drain pans and pumps shall be fitted with water detectors set up to shut down the cooling process and send an alarm via the BMS. These water detectors are typical for all pumped cooling process condensate units.

1.19 MISCELLANEOUS FANS

- A. Mechanical Room and Shop Exhaust
 - 1. F-3 shall start by each and all of the following: A manual timer switch (0-60 minutes) or a space temperature (80 degrees F adjustable) and as indexed by the DDC system as a time of day or cycle function
- B. Typical Toilet and Chemical Storage Exhaust Fans
 - 1. Fan shall start and stop via the DDC system concurrent with respective RTU operation and the general daily occupied schedule. Otherwise fan shall be off and the motorized isolation damper shall be closed
- C. Vehicle Exhaust System
 - 1. F-5 and 7 shall start by each and all of the following: A manual timer switch (0-60 minutes), carbon monoxide detectors (10 ppm set point), and as indexed by the DDC system as a time of day or cycle function.
 - a. When activated by the carbon monoxide detector, an alarm shall be sent to the DDC system at the 10 ppm set point. If the carbon monoxide level increases to 20 ppm or more, an alarm shall be sent to the fire alarm system.
- D. Laser Cutter Exhaust
 - 1. The laser cutter exhaust fan shall be controlled by a manual switch accessible by the supervising teacher. The switch shall open the respective exhaust fan motorized damper and via the fan starter shall energize the exhaust fan and close a pilot indicating relay. Whenever the laser cutter exhaust fan is energized, the respective exhaust VAV terminal shall be indexed to the normal setting minus the laser cutter exhaust fan airflow.
 - 2. A red LED pilot light adjacent to the manual timer switch shall be provided by ATC to indicate "Hood Exhaust Fan ON" status via a current relay.
- E. Spray Booth, Mixing Booth, and Powder Coating Oven Exhaust
 - 1. The exhaust fans serving the spray booth, mixing booth, and powder coating oven shall be interlocked with the operation of each booth.

1.20 ELECTRIC DUCT COIL

- A. The space temperature set point for Pool Mechanical Room 109 shall be 55 degrees. The electric duct coil shall modulate upon a call for heat (space temperature below space temperature set point) to maintain the space temperature setpoint.

1.21 KITCHEN AND CULINARY MAKE-UP AIR AND EXHAUST

- A. Kitchen exhaust fans (KEF) shall be off during unoccupied hours and isolation dampers shall be closed.
- B. At the start of occupied hours MAU-1 and 2 and KEFs shall be energized to their respective low speed settings of 33% of maximum.
- C. ATC system shall communicate with each kitchen hood demand control ventilation control panels (XX total) to receive alarms and temperature readings. Kitchen exhaust fans shall remain at low speed and terminal box at minimum airflow until at least one duct temperature sensor measures 85°F DB (adjustable). At this point associated exhaust fan shall be indexed to 2/3 speed and terminal box indexed to full airflow. System operation shall remain until temperature rises above 95°F DB (adjustable). At this point associated exhaust fan shall be indexed to full speed and terminal box shall remain at full air flow. Terminal box hot water coil shall modulate to maintain space temperature set point (72°F winter, 75°F summer). Field wiring of demand control ventilation system control panel and sensor shall be provided by ATC Contractor.

1.22 LOSS OF POWER – BUILDING FREEZE PROTECTION

- A. Upon a loss of power, as determined by monitoring of the emergency generator, all systems shall be indexed to night set back mode to maintain space night set back heating temperature. Cooling shall be disabled.
- B. Once power is restored, as determined by monitoring of the emergency generator, systems shall enter their normal scheduled operating mode.

1.23 DOMESTIC HOT WATER

- A. BAS shall monitor the domestic hot water heaters via the domestic hot water heater manufacturer provided Modbus alarm and communications interface.
- B. Domestic hot water recirculation pumps shall be monitored via a current sensor.

1.24 PRE-OCCUPANCY BUILDING FLUSH OUT:

- A. Prior to initial occupancy and after completion of all interior finishes, the building shall be flushed out using the permanent HVAC systems operating at normal design minimum outside airflow rates.
- B. Prior to flush out, install MERV-10 filter media over all return air openings.
- C. Operate all air handling systems continuously for a total period of 30 days with outside air set to normal design outside air flow rates, not reduced minimum flow rates.
- D. All spaces shall be controlled to normal heating and cooling space set point during flush out. At no time shall the space temperature be below 60°F nor space humidity be above 60% RH. Provide temporary humidity recorders in representative areas to document space humidity conditions.
- E. Upon completion of flush out period, remove temporary filter media and install design pre-filters and final filters in all units

- F. Provide hourly trend data during the flush out period indicating air handling system status, outside airflow, and space temperature. Also provide humidity data from temporary humidity recorder.

1.25 POINTS LIST:

- A. ATC Subcontractor shall submit a complete list of devices, units, and sensing, associated with the system. The following is a partial list of points for monitoring, alarming, and modifying. Provide additional points to provide the sequences outlines or as indicated elsewhere to provide a complete an operable system. Provide Owner the capability to create displays of each system, as well as all points.
- B. All software, hardware, and commissioning, shall be provided to make a completely integrated system.
- C. Point List: Submit complete list of devices of elements to be controlled or sensed by system. Include sufficient detail to enable engineer and Owner to determine that system can perform control sequence of operations listed in HVAC specifications. Point count must contain at least 125 percent capacity of all points instrumented for control of sequences. These points shall be displayed at the head end workstation.
1. List of every component to be sensed or controlled keyed to terminology used in HVAC Control Drawings (Valve V-1, HVAC-1).
 2. List of hardware associated with each point (e.g., solenoids, contactors, transducers).
 3. List of analog inputs to be sensed at each point (e.g., temperature, relative humidity).
 4. Alarms associated with each point.
 5. Control functions associated with each point (e.g., start/stop, set point control).
 6. The following is a list of the minimum points that shall be tied into the field panels for monitoring, control, and alarm. As a minimum provide these points. Provide additional points as necessary for all sequences to provide a complete and operable system.
 7. Where more than one fan or pump is listed under an item, a separate point is required for each fan and pump unless noted otherwise. Provide occupied/unoccupied override capability at each panel.
 8. Indoor Air Handling, Rooftop and Heat Recovery Units Indication and Sensor Locations:
 - a. Discharge Air Temperature (in supply duct, after all coils).
 - b. Return Air Temperature (upstream of return fan).
 - c. Air Volume, Supply and Return Fans, CFM.
 - d. Return Air Humidity.
 - e. Duct Smoke Detector Status.
 - f. CO₂ Concentration.
 - g. Outdoor CO₂ Baseline Concentration.
 - h. Filter Status - pressure drops, sum of both stages, each bank.
 - i. Supply Fan Run Status.
 - j. Return Fan Run Status.
 - k. Outside Air Volume, CFM
 - l. Mixed Air Temperature (downstream of filters).
 - m. Heat Recovery Leaving Supply Temperature
 - n. Outside Air Temperature
 9. Variable Frequency Drives:
 - a. Output Frequency.
 - b. Motor Current.
 - c. Percent Motor Power.

- d. kWH Energy - Reportable to the BMS for pump energy trending.
 - e. Drive Fault.
 - f. Drive Running.
 - 10. Smoke Damper Indication:
 - a. Smoke Damper Status, Open/Closed
 - 11. Air Terminal Devices:
 - a. Room Temperature
 - b. Air Flow (CFM).
 - c. Inadequate Cooling (V-TUC)
 - d. Inadequate Heating (V-TUC)
 - 12. On/Off Manual or Override Control.
 - a. Fans and air handling units as noted in sequences and schedule.
 - b. Pumps, pool water.
 - 13. Set Point Adjustment
 - a. Air Handling Unit Air Flow (CFM) indexed to occupancy type/mode.
 - b. Air Handling Unit Supply Air Temperature
 - c. Air Handling Unit Outside Air Flow (CFM)
 - d. Air Handling Unit Outside Air Damper Minimum CFM position.
 - e. Air Handling Unit Preheat/Reheat Coil Discharge Temperature
 - f. Room Temperature and set point band imitative.
 - 14. Alarm Indication (Equipment suppliers to provide spare dry contacts)
 - a. Room Temperatures - high and low. Provide low temperature alarm for any space that is below 50 degrees F (adj.) for more than 30 minutes.
 - b. Air Handling Unit Parameters- General Trouble
 - c. Heat Recovery Wheel Parameters- General Trouble
- 1.26 ADDITIONAL MONITORING POINTS:
- A. Fire alarm system status indication, both building general fire alarm indication and atrium smoke exhaust system indication.
 - B. Building main electrical meters.
 - C. Building main water meter.
 - D. Domestic Hot Water Heaters.
 - E. Domestic Hot Water Circulation Pumps.
 - F. Lighting control system (BACnet interface).
 - G. Elevator sump pumps.
 - H. Kitchen and Culinary freezer and cooler dry contacts (4 total).

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION (NOT APPLICABLE)

END OF SECTION

SECTION 232300

REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Refrigerant pipes and fittings.
 - 2. Refrigerant piping valves and specialties.
 - 3. Refrigerants.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of valve and refrigerant piping specialty.
 - 1. Include pressure drop, based on manufacturer's test data, for the following:
 - a. Thermostatic expansion valves.
 - b. Solenoid valves.
 - c. Hot-gas bypass valves.
 - d. Filter dryers.
 - e. Strainers.
 - f. Pressure-regulating valves.
- B. Shop Drawings:
 - 1. Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes; flow capacities; valve arrangements and locations; slopes of horizontal runs; oil traps; double risers; wall and floor penetrations; and equipment connection details.
 - 2. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
 - 3. Show interface and spatial relationships between piping and equipment.
 - 4. Shop Drawing Scale: 1/4 inch equals 1 foot.

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to 2010 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
- B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.7 PRODUCT STORAGE AND HANDLING

- A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-410A:
 - 1. Suction Lines for Air-Conditioning Applications: 300 psig.
 - 2. Suction Lines for Heat-Pump Applications: 535 psig.
 - 3. Hot-Gas and Liquid Lines: 535 psig.

2.2 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 280, Type ACR.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Brazing Filler Metals: AWS A5.8/A5.8M.
- E. Flexible Connectors:
 - 1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
 - 2. End Connections: Socket ends.
 - 3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
 - 4. Working Pressure Rating: Factory test at minimum 500 psig.
 - 5. Maximum Operating Temperature: 250 deg F.

2.3 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as selected in piping application articles.

- B. Wrought-Steel Fittings: ASTM A 234/A 234M, for welded joints.
- C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.
- D. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- E. Flanged Unions:
 - 1. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2 and ductile iron for NPS 2 to NPS 3. Apply rust-resistant finish at factory.
 - 2. Gasket: Fiber asbestos free.
 - 3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
 - 4. End Connections: Brass tailpiece adapters for connections to copper tubing.
 - 5. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
 - 6. Pressure Rating: Factory test at minimum 400 psig.
 - 7. Maximum Operating Temperature: 330 deg F.
- F. Flexible Connectors:
 - 1. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wire-reinforced protective jacket.
 - 2. End Connections:
 - a. NPS 2 and Smaller: With threaded-end connections.
 - b. NPS 2-1/2 and Larger: With flanged-end connections.
 - 3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
 - 4. Pressure Rating: Factory test at minimum 500 psig.
 - 5. Maximum Operating Temperature: 250 deg F.

2.4 VALVES AND SPECIALTIES

- A. Diaphragm Packless Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.
 - c. Parker Hannifin Corp.
 - d. Paul Mueller Company.
 - 2. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
 - 3. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
 - 4. Operator: Rising stem and hand wheel.
 - 5. Seat: Nylon.
 - 6. End Connections: Socket, union, or flanged.
 - 7. Working Pressure Rating: 500 psig.

8. Maximum Operating Temperature: 275 deg F.

B. Packed-Angle Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.
 - c. Parker Hannifin Corp.
 - d. Paul Mueller Company.
2. Body and Bonnet: Forged brass or cast bronze.
3. Packing: Molded stem, back seating, and replaceable under pressure.
4. Operator: Rising stem.
5. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
6. Seal Cap: Forged-brass or valox hex cap.
7. End Connections: Socket, union, threaded, or flanged.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 deg F.

C. Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Emerson Climate Technologies.
 - c. Heldon Products; Henry Technologies.
 - d. Parker Hannifin Corp.
 - e. Paul Mueller Company.
2. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
3. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
4. Piston: Removable polytetrafluoroethylene seat.
5. Closing Spring: Stainless steel.
6. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
7. End Connections: Socket, union, threaded, or flanged.
8. Maximum Opening Pressure: 0.50 psig.
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 275 deg F.

D. Service Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Emerson Climate Technologies.
 - c. Heldon Products; Henry Technologies.
 - d. Parker Hannifin Corp.
 - e. Paul Mueller Company.
 - f. Refrigeration Sales, Inc.

2. Body: Forged brass with brass cap including key end to remove core.
 3. Core: Removable ball-type check valve with stainless-steel spring.
 4. Seat: Polytetrafluoroethylene.
 5. End Connections: Copper spring.
 6. Working Pressure Rating: 500 psig.
- E. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory (NRTL).
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Emerson Climate Technologies.
 - c. Heldon Products; Henry Technologies.
 - d. Parker Hannifin Corp.
 - e. Paul Mueller Company.
 2. Body and Bonnet: Plated steel.
 3. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
 4. Seat: Polytetrafluoroethylene.
 5. End Connections: Threaded.
 6. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-V ac coil.
 7. Working Pressure Rating: 400 psig.
 8. Maximum Operating Temperature: 240 deg F.
- F. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.
 - c. Parker Hannifin Corp.
 - d. Paul Mueller Company.
 2. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
 3. Piston, Closing Spring, and Seat Insert: Stainless steel.
 4. Seat: Polytetrafluoroethylene.
 5. End Connections: Threaded.
 6. Working Pressure Rating: 400 psig.
 7. Maximum Operating Temperature: 240 deg F.
- G. Thermostatic Expansion Valves: Comply with AHRI 750.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Emerson Climate Technologies.
 - c. Heldon Products; Henry Technologies.
 - d. Paul Mueller Company.

2. Body, Bonnet, and Seal Cap: Forged brass or steel.
3. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
4. Packing and Gaskets: Non-asbestos.
5. Capillary and Bulb: Copper tubing filled with refrigerant charge.
6. Suction Temperature: 40 deg F.
7. Superheat: Adjustable.
8. Reverse-flow option (for heat-pump applications).
9. End Connections: Socket, flare, or threaded union.
10. Working Pressure Rating: 700 psig.

H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.
 - c. Parker Hannifin Corp.
2. Body, Bonnet, and Seal Cap: Ductile iron or steel.
3. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
4. Packing and Gaskets: Non-asbestos.
5. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
6. Seat: Polytetrafluoroethylene.
7. Equalizer: Internal.
8. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter and 24-V ac coil.
9. End Connections: Socket.
10. Throttling Range: Maximum 5 psig.
11. Working Pressure Rating: 500 psig.
12. Maximum Operating Temperature: 240 deg F.

I. Straight-Type Strainers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.
 - c. Parker Hannifin Corp.
2. Body: Welded steel with corrosion-resistant coating.
3. Screen: 100-mesh stainless steel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

J. Angle-Type Strainers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.
 - c. Parker Hannifin Corp.

2. Body: Forged brass or cast bronze.
3. Drain Plug: Brass hex plug.
4. Screen: 100-mesh monel.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

K. Moisture/Liquid Indicators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Emerson Climate Technologies.
 - c. Heldon Products; Henry Technologies.
 - d. Parker Hannifin Corp.
2. Body: Forged brass.
3. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
4. Indicator: Color coded to show moisture content in parts per million (ppm).
5. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
6. End Connections: Socket or flare.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 240 deg F.

L. Replaceable-Core Filter Dryers: Comply with AHRI 730.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Emerson Climate Technologies.
 - c. Heldon Products; Henry Technologies.
 - d. Parker Hannifin Corp.
2. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
3. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
4. Desiccant Media: Activated alumina or charcoal.
5. Designed for reverse flow (for heat-pump applications).
6. End Connections: Socket.
7. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
8. Maximum Pressure Loss: 2 psig.
9. Working Pressure Rating: 500 psig.
10. Maximum Operating Temperature: 240 deg F.

M. Permanent Filter Dryers: Comply with AHRI 730.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Emerson Climate Technologies.

- c. Heldon Products; Henry Technologies.
 - d. Parker Hannifin Corp.
- 2. Body and Cover: Painted-steel shell.
 - 3. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
 - 4. Desiccant Media: Activated alumina or charcoal.
 - 5. Designed for reverse flow (for heat-pump applications).
 - 6. End Connections: Socket.
 - 7. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
 - 8. Maximum Pressure Loss: 2 psig.
 - 9. Working Pressure Rating: 500 psig.
 - 10. Maximum Operating Temperature: 240 deg F.

N. Mufflers:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Emerson Climate Technologies.
 - c. Heldon Products; Henry Technologies.
- 2. Body: Welded steel with corrosion-resistant coating.
- 3. End Connections: Socket or flare.
- 4. Working Pressure Rating: 500 psig.
- 5. Maximum Operating Temperature: 275 deg F.

O. Receivers: Comply with AHRI 495.

- 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Emerson Climate Technologies.
 - b. Heldon Products; Henry Technologies.
 - c. Parker Hannifin Corp.
- 2. Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
- 3. Comply with UL 207; listed and labeled by an NRTL.
- 4. Body: Welded steel with corrosion-resistant coating.
- 5. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
- 6. End Connections: Socket or threaded.
- 7. Working Pressure Rating: 500 psig.
- 8. Maximum Operating Temperature: 275 deg F.

P. Liquid Accumulators: Comply with AHRI 495.

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Emerson Climate Technologies.
 - b. Heldon Products; Henry Technologies.
 - c. Parker Hannifin Corp.

2. Body: Welded steel with corrosion-resistant coating.
3. End Connections: Socket or threaded.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

2.5 REFRIGERANTS

- A. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arkema Inc.
 - b. DuPont Fluorochemicals Div.
 - c. Genetron Refrigerants; Honeywell International Inc.
 - d. Mexichem Fluor Inc.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-410A

- A. All refrigerant piping for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Install packed-angle valves in suction and discharge lines of compressor.
- B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.
- C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.
- D. Except as otherwise indicated, install packed-angle valves on inlet and outlet side of filter dryers.
- E. Install a full-size, three-valve bypass around filter dryers.
- F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.
- G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
 1. Install valve so diaphragm case is warmer than bulb.
 2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- H. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.
- I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

- J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:
 - 1. Solenoid valves.
 - 2. Thermostatic expansion valves.
 - 3. Hot-gas bypass valves.
 - 4. Compressor.
- K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.
- L. Install receivers sized to accommodate pump-down charge.
- M. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- B. Install refrigerant piping according to ASHRAE 15.
- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping adjacent to machines to allow service and maintenance.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC" for solenoid valve controllers, control wiring, and sequence of operation.
- K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

- M. Install refrigerant piping in protective conduit where installed belowground.
- N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- O. Slope refrigerant piping as follows:
 - 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Install traps and double risers to entrain oil in vertical runs.
 - 4. Liquid lines may be installed level.
- P. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- Q. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:
 - 1. Shot blast the interior of piping.
 - 2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
 - 3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
 - 4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
 - 5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
 - 6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.
- R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- S. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."
- T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

- C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.
- D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - 1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
 - 2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.
- E. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and to restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- F. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.
- G. Welded Joints: Construct joints according to AWS D10.12M/D10.12.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.5 HANGERS AND SUPPORTS

- A. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
 - 2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.
 - 5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- C. Install hangers for copper tubing with the following maximum spacing and minimum rod diameters:
 - 1. NPS 1/2: Maximum span, 60 inches; minimum rod, 1/4 inch.
 - 2. NPS 5/8: Maximum span, 60 inches; minimum rod, 1/4 inch.
 - 3. NPS 1: Maximum span, 72 inches; minimum rod, 1/4 inch.
 - 4. NPS 1-1/4: Maximum span, 96 inches; minimum rod, 3/8 inch.
 - 5. NPS 1-1/2: Maximum span, 96 inches; minimum rod, 3/8 inch.
 - 6. NPS 2: Maximum span, 96 inches; minimum rod, 3/8 inch.
 - 7. NPS 2-1/2: Maximum span, 108 inches; minimum rod, 3/8 inch.
 - 8. NPS 3: Maximum span, 10 feet; minimum rod, 3/8 inch.
 - 9. NPS 4: Maximum span, 12 feet; minimum rod, 1/2 inch.

- D. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 2: Maximum span, 10 feet; minimum rod, 3/8 inch.
 - 2. NPS 2-1/2: Maximum span, 11 feet; minimum rod, 3/8 inch.
 - 3. NPS 3: Maximum span, 12 feet; minimum rod, 3/8 inch.
 - 4. NPS 4: Maximum span, 14 feet; minimum rod, 1/2 inch.
- E. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Comply with ASME B31.5, Chapter VI.
 - 2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
 - 3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.
 - a. Fill system with nitrogen to the required test pressure.
 - b. System shall maintain test pressure at the manifold gage throughout duration of test.
 - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.
- B. Prepare test and inspection reports.

3.7 SYSTEM CHARGING

- A. Charge system using the following procedures:
 - 1. Install core in filter dryers after leak test but before evacuation.
 - 2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
 - 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
 - 4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
 2. Verify that compressor oil level is correct.
 3. Open compressor suction and discharge valves.
 4. Open refrigerant valves except bypass valves that are used for other purposes.
 5. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION

SECTION 233113

METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Double-wall rectangular ducts and fittings.
3. Single-wall round ducts and fittings.
4. Double-wall round ducts and fittings.
5. Dust Collector exhaust ducts and fittings.
6. Sheet metal materials.
7. Duct liner.
8. Sealants and gaskets.
9. Hangers and supports.

- B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".>
- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
3. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."
4. Duct-Cleaning Test Report for Prerequisite IEQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-up."
5. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
6. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

D. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations for selecting hangers and supports.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.

6. Items penetrating finished ceiling including the following:

- a. Lighting fixtures.
- b. Air outlets and inlets.
- c. Speakers.
- d. Sprinklers.
- e. Access panels.
- f. Perimeter moldings.

B. Welding certificates.

C. Field quality-control reports.

D. Leak Test Procedures: Including test pressures, ductwork system definition and method for approving each system.

E. Leak Test Manual: As indicated.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports and AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. Welding Qualifications: Qualify procedures and personnel according to the following:

- 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
- 2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. McGill AirFlow LLC.
 - 2. MKT Metal Manufacturing.
 - 3. Sheet Metal Connectors, Inc.
- B. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.
- C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated. Minimum 0.031-inch galvanized sheet steel.
- D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Button punch snap lock seams shall not be allowed.
- F. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
 - 1. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
- G. Inner Duct: Minimum 0.031-inch perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent.
- H. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- I. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SINGLE-WALL ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated. No duct metal gauges thinner than 24 gauge will be acceptable.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ductmate Industries, Inc.
 - b. Lindab Inc.
 - c. McGill AirFlow LLC.
 - d. MKT Metal Manufacturing.
 - e. SEMCO LLC.
 - f. Sheet Metal Connectors, Inc.
 - g. Spiral Manufacturing Co., Inc.
- B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
- C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
- D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
 2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
- E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 DOUBLE-WALL ROUND DUCTS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Linx Industries; a DMI company (formerly Lindab).
 2. MKT Metal Manufacturing.
 3. McGill AirFlow LLC.

4. SEMCO, LLC; part of FlaktGroup.
 5. SHAPE Manufacturing Inc.
 6. Set Duct Manufacturing.
 7. Sheet Metal Connectors, Inc.
- B. Source Limitations: Obtain double-wall round ducts and fittings from single manufacturer.
- C. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.
- D. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
1. Construct ducts of galvanized sheet steel unless otherwise indicated.
 2. For ducts exposed to weather, construct outer duct of Type 316 stainless steel indicated by manufacturer to be suitable for outdoor installation.
 3. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
 4. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
 - b. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
 5. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- E. Inner Duct: Minimum 24-gauge solid galvanized sheet steel.
- F. Interstitial Insulation, Fibrous Glass: Duct liner complying with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
 2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 3. Coat insulation with antimicrobial coating.
 4. Cover insulation with polyester film complying with UL 181, Class 1.

2.5 SINGLE-WALL GREASE DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "Kitchen Ventilation Systems and Food Service Equipment Guidelines" and "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- B. Construct concealed kitchen range hood exhaust ducts, including the plenum, to and through the roof, and the ductwork on the outlet side of the fan of minimum No. 12 gage black iron.
- C. Seams and joints shall be externally welded liquid tight using the Carbon Arc Process.

2.6 DOUBLE-WALL ROUND DUCTS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Lindab Inc.
 - 2. McGill AirFlow LLC.
 - 3. MKT Metal Manufacturing.
 - 4. SEMCO LLC.
 - 5. Sheet Metal Connectors, Inc.
- B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.
- C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
 - 1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
 - 2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
 - b. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
 - 3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

- D. Inner Duct: Minimum 24-gauge solid galvanized sheet steel.
- E. Interstitial Insulation, Fibrous Glass: Duct liner complying with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - 1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
 - 2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 - 3. Coat insulation with antimicrobial coating.
 - 4. Cover insulation with polyester film complying with UL 181, Class 1.

2.7 QUICK FIT CLAMP EXHAUST DUCTWORK

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Nordfab.
 - 2. US Duct.
 - 3. KB Duct.
- B. 304SS: Finish meets ASTM A240.
 - 1. Temp rating is 1100°F.
- C. Diameters 3" - 24": Quick-Fit Sleeves (adjustable nipples), and collars attached to other components shall have one or both ends die formed-rolled to provide a uniform edge around the circumference of the rolled end. The pipe and sleeves shall have the longitudinal seam laser welded to allow for a tighter slip joint and reduce system pressure losses. All laser welded seams will undergo a light test to ensure there are no voids or imperfections in the system. Pipe lengths using laser welded seams will not exceed a nominal 60" length. The rolled end is used for clamping components together as well as offering reinforcement. Rolled edges provide structural support at 5' intervals or less and can be interpreted as a stiffener where SMACNA specifications are required.
- D. Clamps shall be constructed with an over-center, spring-lever action for quick connecting of two pieces of ducting. A retaining pin shall be inserted in the handle and an eyelet on the clamp as a safety feature to ensure the handle does not prematurely come undone.
- E. When closing the clamp, the internal seal shall be compressed in such a manner as to cover both rolled beads for optimum sealing capacity in a full 360° pattern.
- F. All clamps shall contain a standard Nitrile gasket.

2.8 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90.
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.

- C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.
- D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.
- E. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- F. Factory- or Shop-Applied Antimicrobial Coating:
 - 1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
 - 2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 - 3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
 - 4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 - 5. Shop-Applied Coating Color: Black.
 - 6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.
- G. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
 - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- H. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.9 DUCT LINER

- A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CertainTeed Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Owens Corning.
 - 1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F conductivity at 75 deg F mean temperature and a minimum NRC rate of 0.70.
 - 2. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.

3. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
 - a. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Insulation Pins and Washers:
 1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel or aluminum (same material as sheet metal); with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."
 1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
 2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
 3. Butt transverse joints without gaps, and coat joint with adhesive.
 4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
 5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
 6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
 7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
 8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 - a. Fan discharges.
 - b. Intervals of lined duct preceding unlined duct.
 - c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.
 9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
 - a. Sheet Metal Inner Duct Perforations: 3/32-inch diameter, with an overall open area of 23 percent.
 10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.10 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 2. Tape Width: 4 inches.
 3. Sealant: Modified styrene acrylic.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 7. Service: Indoor and outdoor.
 8. Service Temperature: Minus 40 to plus 200 deg F.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
 10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 11. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. Water-Based Joint and Seam Sealant:
1. Application Method: Brush on.
 2. Solids Content: Minimum 65 percent.
 3. Shore A Hardness: Minimum 20.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. VOC: Maximum 75 g/L (less water).
 7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 8. Service: Indoor or outdoor.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- D. Flanged Joint Sealant: Comply with ASTM C 920.
1. General: Single-component, acid-curing, silicone, elastomeric.
 2. Type: S.
 3. Grade: NS.
 4. Class: 25.
 5. Use: O.
 6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 7. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum 3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.11 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
- F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
 3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install round ducts in maximum practical lengths.
- D. Install ducts with fewest possible joints.
- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- J. Where ducts pass through non-fire-rated interior partitions and exterior walls, the opening in the construction shall be packed with mineral fireproofing and sealed airtight on both sides with an approved resilient penetration sleeve/seal. Provide angle collars or galvanized steel sheet metal safing as required to cover gap between ductwork and opening. Angle collars shall be required when safing is used for duct support at floors. Overlap openings on four sides by at least 1-1/2 inches.
- K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. The opening in the construction around the duct shall not exceed 1 inch average clearance on all sides and shall be filled solidly with an approved resilient penetration sleeve/seal. Provide angle collars or galvanized steel sheet metal safing as required to cover gap between ductwork and opening. Angle collars shall be required when safing is used for duct support at floors. Overlap openings on four sides by at least 1-1/2 inches. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials.
- M. Piping, conduit and structure shall not penetrate ductwork. Where this condition cannot be avoided and with written approval of Design Professional, follow Figure 2-10 of SMACNA HVAC Duct Construction Standards - Metal and Flexible, except that sides of transition sections shall slope a maximum of 15 degrees.
- N. Unused portions of HVAC supply air and exhaust louvers shall be blanked off with double No. 18 gage galvanized steel sheet metal sandwich, insulated in accordance with Section 230713, unless otherwise indicated.
- O. Welded and scratched galvanized steel surfaces shall be touched up with zinc-rich paint.
- P. Ductwork shall be fabricated, handled and transported with special concern for internal and external cleanliness. Ductwork and fittings shall be wiped clean of grease, dust and other debris both inside and out before delivery to the Project Site and wrapped in 4 mil thick polyethylene plastic for shipment and storage at the Project Site. During installation, open ends shall be secured with 4 mil thick polyethylene plastic at all times prior to joining of duct sections. As each section is joined, the insides shall be vacuumed and resealed. In the event that dirt of any kind is found inside the ductwork during installation, each such section shall be removed from the system and properly cleaned prior to reinstallation. Handling, protection during storage and installation, installation quality, and flushing and cleaning of systems will be witnessed and accepted by Owner's Representative.
- Q. Install quick fit clamp exhaust ductwork per ductwork manufacturer's installation instructions.

3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

- A. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease and sloped a minimum of 2 percent to drain grease back to the hood.
- B. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 20 feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings.
- C. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.4 ADDITIONAL INSTALLATION REQUIREMENTS FOR CLOTHES DRYER EXHAUST DUCT

- A. Install clothes dryer exhaust ducts with a minimum of 6 inches clearance from combustible material. When the ductwork passes through walls, floors, or partitions, the 6 inch space around the duct shall be sealed with noncombustible material.
- B. All ductwork associated with clothes dryer exhaust shall not be assembled using sheetmetal screws or other fastening means that extend into the duct.

3.5 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. All ductwork shall be sealed to Seal Class A.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

- B. Support ductwork hung from building structure using trapeze, strap or angle iron hangers conforming to SMACNA HVAC Duct Construction Standards - Metal and Flexible, [Uniform Mechanical Code. Provide supplemental structural steel to span beams or joists where required. Deflection of supplemental structural steel shall be limited to length/180 of the span.
- C. Do not support ductwork from furring, hung ceilings, metal floor deck, metal roof deck or from another duct or pipe.
- D. Do not hang lighting fixtures or piping from ductwork.
- E. Where duct connects to or terminates at masonry openings or at floors where concrete curbs are not provided, provide a continuous 1 1/2 inch by 1 1/2 inch by 3/16 inch galvanized steel angle support around the ductwork. Bolt and seal the supports to the building construction using expansion bolts and caulking compound. Seal shall be watertight at floor or wall and duct such that a spill will not pass down through the opening.
- F. Fasten plenums and casings connected to concrete curbs using continuous 1 1/2 inch by 1 1/2 inch by 1/4 inch galvanized steel angle support. Set the angle support in a continuous bead of caulking compound and anchor it to the curb with 3/8 inch diameter anchors on 16 inch centers. Terminate sheet metal at curb and bolt to angle support. Seal sheet metal to curb with a continuous bead of caulking.
- G. For insulated ductwork, install hangers on the outside of the insulation. To maintain the insulation value, inset a piece of 1 inch thick, 6 pcf fiberglass board with a foil/scrim/kraft (FSK) jacket at these supports.
- H. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
 - 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- I. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- J. Hangers Exposed to View: Threaded rod and angle or channel supports.
- K. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- L. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.7 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.8 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Leakage Tests:
 - 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual."
 - 2. A written leak test manual shall be prepared prior to construction outlining testing procedures, testing methods, acceptable criteria, leakage factor (F) calculations, and calculation of ductwork surface area for each test section for each system tested. Duct system layouts utilizing sheetmetal shop drawings shall be developed indicating each section to be tested showing surface areas, allowable leakages, and test pressures. Include test form as defined by SMACNA with leakage class, leakage factor allowable leakage cfm listed for each test section. This manual shall be submitted for review and approval prior to starting any duct installation. This manual shall be updated during the construction process and expanded to include all test results, verifications, and approval sign-offs during actual testing
 - 3. Devices, including access doors, sound attenuators, damper casings, sensors and test ports, that are installed in duct systems, shall be included as part of the duct systems leakage allowance and tested accordingly. Air leakage for equipment, such as fans, air handling units and terminal units, have been accounted for separately and equipment has been specified to meet specific air leakage criteria.
 - 4. If allowable leakage is percentage based, then follow Appendix C of SMACNA's "HVAC Air Duct Leakage Test Manual." Include calculation of total system ductwork surface area along with test section surface area calculations within test procedures submittal.
 - 5. If tests show that ductwork leakage is greater than that allowed, ductwork shall be resealed/rewelded and retested until within allowable leakage. Perform rework at no additional cost. Tests will be witnessed, and results verified by Owner's Representative and the Balancing Contractor.
 - 6. If, by test, during testing and balancing of the systems or otherwise, pressure drops across ductwork fittings and duct-mounted devices furnished under other Sections are exceeded by 10 percent of the pressure drop ratings listed in the SMACNA HVAC Duct System Design Manual, inspect inside of ductwork fittings and devices, and report findings to Design Professional. If fittings and devices do not have access doors, cut inspection openings in ductwork, and provide airtight access covers secured with sheet metal screws. Repair or replace fittings and devices, and retest until within allowable pressure drop. Perform rework at no additional cost.

7. If, by test, during testing and balancing of the systems or otherwise, airflow between airflow sources and termination points are exceeded by 10 percent of the allowable leakage airflow for each section in question, review duct system under scrutiny for excessive leakage. Testing and Balancing Contractor shall confirm accuracy and calibration of devices utilized to make measurements. If calibration is confirmed and measured airflow between airflow sources and termination points exceed allowable leakage by 10%, then repeat duct leakage testing at no additional cost. Repair or replace fittings and devices, and retest until within allowable leakage. Perform rework at no additional cost.
 8. Submit a final test manual including procedures and all reports for each test certifying that the ductwork does not exceed the maximum allowable leakage.
 9. Test the following systems:
 - a. Ducts with a Pressure Class Equal to and Higher Than 3-Inch wg: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.
 10. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 11. Test for leaks before applying external insulation.
 12. Conduct tests at static pressures equal to maximum design pressure class of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
 13. Give seven days' advance notice for testing.
- C. Duct System Cleanliness Tests:
1. Visually inspect duct system to ensure that no visible contaminants are present.
 2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
 - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
- D. Duct system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.
- 3.10 DUCT CLEANING
- A. Clean new duct system(s) before testing, adjusting, and balancing.
- B. Use service openings for entry and inspection.
1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 3. Remove and reinstall ceiling to gain access during the cleaning process.
- C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.11 START UP

- A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.12 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated.

1. SMACNA Leakage Class shall be 3 and SMACNA Seal Class shall be A, unless noted otherwise.

- B. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
 - a. Pressure Class: Positive 2-inch wg
 - b. Liner: Flexible elastomeric, 1 inch thick for 20 feet downstream of each terminal unit.
 2. Ducts Connected to Constant-Volume and Variable Air-Handling Units from unit connection to sound attenuator.
 - a. Double wall duct.
 - b. Pressure Class: Positive 6-inch wg
 3. Ducts Connected to Constant-Volume and Variable Air-Handling Units from termination of 6 inch pressure class ductwork complete through to the connection to the terminal unit.
 - a. Single wall duct.
 - b. Pressure Class: Positive 4-inch wg
 - c. Lining: As indicated on plans.
 4. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive 4-inch wg.
- C. Return Ducts:
1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
 - a. Pressure Class: Positive or negative 2-inch wg
 - b. Liner: Flexible elastomeric, 1 inch thick for 15 feet upstream of each terminal unit.
 2. Ducts Connected to Air-Handling Units from unit duct connection to sound attenuator connection:
 - a. Pressure Class: Positive or negative 4-inch wg.
 3. Ducts Connected to Air-Handling Units from termination of 4 inch pressure class ductwork to the connection to the return grille:
 - a. Pressure Class: Positive or negative 2-inch wg.
 4. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive or negative 4-inch wg.
- D. Exhaust Ducts:
1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
 - a. Pressure Class: Positive or negative 2-inch wg.
 - b. Dishwasher Exhaust Ductwork: 304 stainless steel, finish 4, 100% welded
 2. Ducts Connected to Terminal Units:
 - a. Pressure Class: Negative 2-inch wg

- b. Liner: Flexible elastomeric, 1 inch thick for 20 feet upstream of each terminal unit.
- 3. Ducts Connected to Constant-Volume and Variable Air-Handling Units from unit connection to sound attenuator.
 - a. Double wall duct.
 - b. Pressure Class: Negative 6-inch wg
 - c. RTU-2 Ductwork Material: Aluminum
- 4. Ducts Connected to Constant-Volume and Variable Air-Handling Units from termination of 6 inch pressure class ductwork complete through to the connection to the terminal unit.
 - a. Single wall duct.
 - b. Pressure Class: Negative 4-inch wg
 - c. Lining: As indicated on plans.
 - d. RTU-2 Ductwork Material: Aluminum
- 5. Ducts Connected to Commercial Kitchen Hoods: Comply with NFPA 96.
 - a. Concealed: 16 gauge black iron.
 - b. Welded seams and joints.
 - c. Pressure Class: Positive or negative 4-inch wg.
 - d. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
 - e. SMACNA Leakage Class: 3
- 6. Ducts Connected to Clothes Dryers:
 - a. Single wall spiral wound duct.
 - b. Clamped joints.
 - c. Pressure Class: Positive or negative 2-inch wg.
- 7. Ducts Connected to Dust Collector and Vehicle Exhaust System:
 - a. Quick fit clamp.
 - b. Clamped joints.
 - c. Pressure Class: Positive or negative 10-inch wg.
- 8. Ducts Connected to Laser Cutter:
 - a. Single wall spiral wound duct.
 - b. Clamped joints.
 - c. Pressure Class: Positive or negative 10-inch wg.
- E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
 - 1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
 - a. Pressure Class: Positive or negative 2-inch wg.
 - 2. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive or negative 2-inch wg.
- F. Transfer Air Ducts

1. Ducts Transferring Air between spaces:
 - a. Pressure Class: Positive or negative 2-inch wg
 - b. Liner: Flexible elastomeric, 1 inch thick.
 - c. Mitered elbows, no turning vanes.
- G. Intermediate Reinforcement:
 1. Galvanized-Steel Ducts: Galvanized steel.
 2. Aluminum Ducts: Aluminum.
 3. Stainless Ducts: Stainless.
- H. Double-Wall Duct Interstitial Insulation:
 1. 1-1/2 inches thick.
- I. Elbow Configuration:
 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Velocity 1000 fpm or Lower:
 - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 4 without vanes.
 - b. Velocity 1000 to 1500 fpm:
 - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 - c. Velocity 1500 fpm or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

- a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - 4) Radius-to Diameter Ratio: 1.5.
- b. Round Elbows, 8 Inches and Smaller in Diameter: Die-formed from minimum 20 gauge galvanized steel.
- c. Round Elbows, 10 Inches and Larger in Diameter: Welded.

J. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Bellmouth.
2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm or Lower: Conical or Bellmouth tap.
 - b. Velocity 1000 to 1500 fpm: Conical or Bellmouth tap.
 - c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION

SECTION 233114

FIXED LOUVERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Fixed extruded-aluminum louvers.
 - 2. Blank-off panels for louvers

1.2 DEFINITIONS

- A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section unless otherwise defined in this Section or in referenced standards.
- B. Horizontal Louver: Louver with horizontal blades (i.e., the axis of the blades are horizontal).
- C. Vertical Louver: Louver with vertical blades (i.e., the axis of the blades are vertical).
- D. Drainable-Blade Louver: Louver with blades having gutters that collect water and drain it to channels in jambs and mullions, which carry it to bottom of unit and away from opening.
- E. Wind-Driven-Rain-Resistant Louver: Louver that provides specified wind-driven-rain performance, as determined by testing in accordance with AMCA 500-L.
- F. Windborne-Debris-Impact-Resistant Louver: Louver that provides specified windborne-debris-impact resistance, as determined by testing in accordance with AMCA 540.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. For louvers specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.
- B. Shop Drawings: For louvers and accessories. Include plans, elevations, sections, details, and attachments to other work. Show frame profiles and blade profiles, angles, and spacing.
 - 1. Show weep paths, gaskets, flashings, sealants, and other means of preventing water intrusion.
 - 2. Show mullion profiles and locations.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Test Reports: Based on evaluation of comprehensive tests performed in accordance with AMCA 500-L by a qualified testing agency or by manufacturer and witnessed by a qualified testing agency, for each type of louver and showing compliance with performance requirements specified.

- B. Windborne-debris-impact-resistance test reports.
- C. Sample Warranties: For manufacturer's special warranties.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:
 - 1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
 - 2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."

1.6 FIELD CONDITIONS

- A. Field Measurements: Verify actual dimensions of openings by field measurements before fabrication.

1.7 WARRANTY

- A. Special Finish Warranty, Factory-Applied Finishes: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of baked enamel, powder coat, or organic finishes within specified warranty period.
 - 1. Deterioration includes, but is not limited to, the following:
 - a. Color fading more than 5 Delta E units when tested in accordance with ASTM D2244.
 - b. Chalking in excess of a No. 8 rating when tested in accordance with ASTM D4214.
 - c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.
 - 2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Source Limitations: Obtain fixed louvers from single source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.

2.2 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design louvers, including comprehensive engineering analysis by a qualified professional engineer, using structural performance requirements and design criteria indicated.
- B. Structural Performance: Louvers withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of louver components, noise or metal fatigue caused by louver-blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures are considered to act normal to the face of the building.
 - 1. Wind Loads:
 - a. Determine loads based on a uniform pressure of 30 lbf/sq. ft., acting inward or outward.

- C. Louver Performance Ratings: Provide louvers complying with requirements specified, as demonstrated by testing manufacturer's stock units identical to those provided, except for length and width in accordance with AMCA 500-L.
- D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change (Range): 180 deg F (100 deg C), material surfaces
- E. SMACNA Standard: Comply with recommendations in SMACNA's "Architectural Sheet Metal Manual" for fabrication, construction details, and installation procedures.

2.3 FIXED EXTRUDED-ALUMINUM LOUVERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ruskin
 - 2. Pottorff
 - 3. Greenheck
- B. Horizontal Drainable-Blade Louver, Extruded Aluminum:
 - 1. Louver Depth: 6 inches
 - 2. Frame and Blade Nominal Thickness: Not less than 0.060 inch for blades and 0.080 inch (2.03 mm) for frames.
 - 3. Mullion Type: Exposed.
 - 4. Louver Performance Ratings:
 - a. Free Area: Not less than 8.0 sq. ft. for 48-inch- wide by 48-inch-high louver.
 - b. Point of Beginning Water Penetration: Not less than 1000 fpm.
 - c. Air Performance:
 - 1) Not more than 0.10-inch wg (25-Pa)] <Insert value> static pressure drop at 750-fpm free-area exhaust and intake velocity.
 - 5. AMCA Seal: Mark units with AMCA Certified Ratings Seal.

2.4 LOUVER SCREENS

- A. General: Provide screen at each exterior louver.
 - 1. Screen Location for Fixed Louvers: Interior face.
 - 2. Screening Type: Bird screening.
- B. Secure screen frames to louver frames with stainless steel machine screws, spaced a maximum of 6 inches (150 mm) from each corner and at 12 inches (300 mm) o.c.
- C. Louver Screen Frames: Fabricate with mitered corners to louver sizes indicated.
 - 1. Metal: Same type and form of metal as indicated for louver to which screens are attached. Reinforce extruded-aluminum screen frames at corners with clips.
 - 2. Finish: Same finish as louver frames to which louver screens are attached.

D. Louver Screening for Aluminum Louvers:

1. Bird Screening, Aluminum: 1/2-inch- (13-mm-) square mesh, 0.063-inch (1.60-mm) wire.

2.5 BLANK-OFF PANELS

A. Insulated Blank-Off Panels: Laminated panels consisting of an insulating core surfaced on back and front with metal sheets and attached to back of louver.

1. Thickness: 2 inches.
2. Metal Facing Sheets, Aluminum: Not less than 0.032-inch nominal thickness.
3. Insulating Core: Rigid, glass-fiber-board insulation.
4. Edge Treatment: Trim perimeter edges of blank-off panels with louver manufacturer's standard extruded-aluminum-channel frames, not less than 0.080-inch (2.03-mm) nominal thickness, with corners mitered and with same finish as panels.
5. Seal perimeter joints between panel faces and louver frames with gaskets or sealant.
6. Panel Finish: Same type of finish applied to louvers, but black color.
7. Attach blank-off panels with sheet metal screws.

2.6 MATERIALS

A. Aluminum Extrusions: ASTM B221 (ASTM B221M), Alloy 6063-T5, T-52, or T6.

B. Aluminum Sheet: ASTM B209 (ASTM B209M), Alloy 3003 or 5005, with temper as required for forming, or as otherwise recommended by metal producer for required finish.

C. Fasteners: Use types and sizes to suit unit installation conditions.

1. Use tamper-resistant screws for exposed fasteners unless otherwise indicated.
2. For fastening aluminum, use aluminum or 300 series stainless steel fasteners.
3. For fastening galvanized steel, use hot-dip-galvanized-steel or 300 series stainless steel fasteners.
4. For fastening stainless steel, use 300 series stainless steel fasteners.
5. For color-finished louvers, use fasteners with heads that match color of louvers.

D. Post installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors, fabricated from stainless steel components, with allowable load or strength design capacities calculated in accordance with ICC-ES AC193 and ACI 318 greater than or equal to the design load, as determined by testing in accordance with ASTM E488/E488M conducted by a qualified testing agency.

E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.

2.7 FABRICATION

A. Factory assemble louvers to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.

B. Vertical Assemblies: Where height of louver units exceeds fabrication and handling limitations, fabricate units to permit field-bolted assembly with close-fitting joints in jambs and mullions, reinforced with splice plates.

- C. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
 - 1. Frame Type: Integral exterior flange unless otherwise indicated.
- D. Include supports, anchorages, and accessories required for complete assembly.
- E. Provide vertical mullions of type and at spacings indicated, but not more than is recommended by manufacturer.
 - 1. Exposed Mullions: Where indicated, provide units with exposed mullions of same width and depth as louver frame. Where length of louver exceeds fabrication and handling limitations, provide interlocking split mullions designed to permit expansion and contraction.
- F. Provide extended sills for recessed louvers.
- G. Join frame members to each other and to fixed louver blades with fillet welds concealed from view unless otherwise indicated or size of louver assembly makes bolted connections between frame members necessary.

2.8 ALUMINUM FINISHES

- A. Finish louvers after assembly.
- B. Baked-Enamel or Powder-Coat Finish: AAMA 2603. Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
 - 1. Color and Gloss: Custom color as selected by Architect.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Coordinate setting drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.3 INSTALLATION

- A. Locate and place louvers level, plumb, and at indicated alignment with adjacent work.
- B. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.
- C. Form closely fitted joints with exposed connections accurately located and secured.

- D. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- E. Protect unpainted galvanized- and nonferrous-metal surfaces that are in contact with concrete, masonry, or dissimilar metals from corrosion and galvanic action by applying a heavy coating of bituminous paint or by separating surfaces with waterproof gaskets or nonmetallic flashing.
- F. Install concealed gaskets, flashings, joint fillers, and insulation as louver installation progresses, where weathertight louver joints are required. Comply with Section 079200 "Joint Sealants" for sealants applied during louver installation.

3.4 ADJUSTING AND CLEANING

- A. Clean exposed louver surfaces that are not protected by temporary covering, to remove fingerprints and soil during construction period. Do not let soil accumulate during construction period.
- B. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.
- C. Restore louvers damaged during installation and construction, so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.
 - 1. Touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

END OF SECTION

SECTION 233300

AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Barometric relief dampers.
3. Manual volume dampers.
4. Control dampers.
5. Fire dampers.
6. Smoke dampers.
7. Combination fire and smoke dampers.
8. Flange connectors.
9. Duct silencers.
10. Turning vanes.
11. Remote damper operators.
12. Duct-mounted access doors.
13. Flexible connectors.
14. Flexible ducts.
15. Duct accessory hardware.

- B. Related Requirements:

1. Section 283111 "Digital, Addressable Fire-Alarm System" for duct-mounted fire and smoke detectors.
2. Section 283112 "Zoned (DC-Loop) Fire-Alarm System" for duct-mounted fire and smoke detectors.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

- B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct insulation R-values comply with tables in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air Conditioning."

- C. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
 - 1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances, and method of field assembly into duct systems and other construction. Include the following:
 - a. Special fittings.
 - b. Manual volume damper installations.
 - c. Control-damper installations.
 - d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
 - e. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.
- B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

- A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90.
 - 2. Exposed-Surface Finish: Mill phosphatized.

- B. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- C. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.
- D. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- E. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. American Warming and Ventilating; a Mestek Architectural Group company.
 - 2. Cesco Products; a division of MESTEK, Inc.
 - 3. Flex-Tek Group.
 - 4. Greenheck Fan Corporation.
 - 5. Lloyd Industries, Inc.
 - 6. Nailor Industries Inc.
 - 7. NCA Manufacturing, Inc.
 - 8. Pottorff.
 - 9. Ruskin Company.
 - 10. Vent Products Co., Inc.
- B. Description: Gravity balanced.
- C. Maximum Air Velocity: 2000 fpm.
- D. Maximum System Pressure: 6-inch wg.
- E. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with welded corners or mechanically attached and mounting flange.
- F. Blades: Multiple single-piece blades, center pivoted, maximum 6-inch width, 0.050-inch-thick aluminum sheet with sealed edges.
- G. Blade Action: Parallel.
- H. Blade Seals: Neoprene, mechanically locked.
- I. Blade Axles:
 - 1. Material: Galvanized steel.
 - 2. Diameter: 0.20 inch.
- J. Tie Bars and Brackets: Galvanized steel.
- K. Return Spring: Adjustable tension.
- L. Bearings: Steel ball or synthetic pivot bushings.

M. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Chain pulls.
5. Screen Mounting: Front mounted in sleeve.
 - a. Sleeve Thickness: 20 gage minimum.
 - b. Sleeve Length: 6 inches minimum.
6. Screen Mounting: Rear mounted.
7. Screen Material: Aluminum.
8. Screen Type: Bird.
9. 90-degree stops.

2.4 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aire Technologies.
 - b. American Warming and Ventilating; a Mestek Architectural Group company.
 - c. Flexmaster U.S.A., Inc.
 - d. Flex-Tek Group.
 - e. McGill AirFlow LLC.
 - f. Nailor Industries Inc.
 - g. Pottorff.
 - h. Ruskin Company.
 - i. Trox USA Inc.
 - j. Vent Products Co., Inc.
2. Standard leakage rating.
3. Suitable for horizontal or vertical applications.
4. Frames:
 - a. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized steel, 0.064 inch thick.
6. Blade Axles: Galvanized steel.
7. Bearings:
 - a. Oil-impregnated bronze.

- b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
- 8. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Warming and Ventilating; a Mestek Architectural Group company.
 - b. McGill AirFlow LLC.
 - c. Nailor Industries Inc.
 - d. Pottorff.
 - e. Ruskin Company.
 - f. Trox USA Inc.
 - g. Vent Products Co., Inc.
- 2. Standard leakage rating, with linkage outside airstream.
- 3. Suitable for horizontal or vertical applications.
- 4. Frames: Hat-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
- 5. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Roll-Formed Aluminum Blades: 0.10-inch-thick aluminum sheet.
 - e. Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.
- 6. Blade Axles: Nonferrous metal.
- 7. Bearings:
 - a. Molded synthetic
 - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
- 8. Tie Bars and Brackets: Aluminum.

C. Jackshaft:

- 1. Size: 0.5-inch diameter.
- 2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
- 3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

D. Damper Hardware:

- 1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
- 2. Include center hole to suit damper operating-rod size.
- 3. Include elevated platform for insulated duct mounting.

2.5 CONTROL DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. American Warming and Ventilating; a Mestek Architectural Group company.
 2. Arrow United Industries.
 3. Cesco Products; a division of MESTEK, Inc.
 4. Flex-Tek Group.
 5. Greenheck Fan Corporation.
 6. Lloyd Industries, Inc.
 7. McGill AirFlow LLC.
 8. Metal Form Manufacturing, Inc.
 9. Nailor Industries Inc.
 10. NCA Manufacturing, Inc.
 11. Pottorff.
 12. Ruskin Company.
 13. Vent Products Co., Inc.
 14. Young Regulator Company.
- B. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
- C. Frames:
1. Hat shaped.
 2. 0.094-inch-thick, galvanized sheet steel
 3. Mitered and welded corners.
- D. Blades:
1. Multiple blade with maximum blade width of 8 inches.
 2. Parallel- and opposed-blade design.
 3. Galvanized-steel.
 4. 0.0747-inch-thick dual skin.
 5. Blade Edging: PVC.
 6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.
- E. Blade Axles: 1/2-inch-diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
1. Operating Temperature Range: From minus 40 to plus 200 deg F.
- F. Bearings:
1. Oil-impregnated bronze.
 2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 3. Thrust bearings at each end of every blade.

2.6 FIRE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Aire Technologies.
 2. American Warming and Ventilating; a Mestek Architectural Group company.
 3. Arrow United Industries.
 4. Cesco Products; a division of MESTEK, Inc.
 5. Greenheck Fan Corporation.
 6. Nailor Industries Inc.
 7. NCA Manufacturing, Inc.
 8. Pottorff.
 9. Prefco.
 10. Ruskin Company.
 11. Vent Products Co., Inc.
 12. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.
- C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
- D. Fire Rating: 1-1/2 hours and up to 1800 degrees F. Provide 3 and 4 hour rating where noted on the drawings and coordinated to maintain ratings.
- E. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.
- F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
1. Minimum Thickness: 0.138 inch thick, as indicated, and of length to suit application.
 2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- G. Mounting Orientation: Vertical or horizontal as indicated.
- H. Blades: Roll-formed, interlocking, 0.034-inch thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.
- I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- J. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.
- 2.7 SMOKE DAMPERS
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Aire Technologies.
 2. American Warming and Ventilating; a Mestek Architectural Group company.
 3. Cesco Products; a division of MESTEK, Inc.
 4. Greenheck Fan Corporation.
 5. Nailor Industries Inc.
 6. Pottorff.
 7. Ruskin Company.
- B. General Requirements: Label according to UL 555S by an NRTL.

- C. Smoke Detector: Integral, factory wired for single-point connection.
- D. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with welded corners and mounting flange.
- E. Blades: Roll-formed, horizontal, interlocking, 0.034-inch thick, galvanized sheet steel.
- F. Leakage: Class I.
- G. Rated pressure and velocity to exceed design airflow conditions.
- H. Mounting Sleeve: Factory-installed, 0.05-inch thick, galvanized sheet steel; length to suit wall or floor application.
- I. Damper Motors: Two-position action.
- J. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 - 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 - 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
 - 5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
 - 6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
 - 7. Electrical Connection: 115 V, single phase, 60 Hz.
- K. Accessories:
 - 1. Auxiliary switches for position indication.
 - 2. Test and reset switches, damper mounted.

2.8 COMBINATION FIRE AND SMOKE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Aire Technologies.
 - 2. American Warming and Ventilating; a Mestek Architectural Group company.
 - 3. Cesco Products; a division of MESTEK, Inc.
 - 4. Greenheck Fan Corporation.
 - 5. Nailor Industries Inc.
 - 6. Pottorff.

7. Ruskin Company.
 - B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.
 - C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
 - D. Fire Rating: 1-1/2 and 3 hours.
 - E. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with welded corners.
 - F. Heat-Responsive Device: Electric resettable device and switch package, factory installed, rated.
 - G. Smoke Detector: Integral, factory wired for single-point connection.
 - H. Blades: Roll-formed, horizontal, interlocking, 0.063-inch thick, galvanized sheet steel.
 - I. Leakage: Class I.
 - J. Rated pressure and velocity to exceed design airflow conditions.
 - K. Mounting Sleeve: Factory-installed, 0.05-inch-thick, galvanized sheet steel; length to suit wall or floor application.
 - L. Master control panel for use in dynamic smoke-management systems.
 - M. Damper Motors: Two-position action.
 - N. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
 5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
 6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
 7. Electrical Connection: 115 V, single phase, 60 Hz.
 - O. Accessories:
 1. Auxiliary switches for position indication.
 2. Test and reset switches, damper mounted.

2.9 FLANGE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CL WARD & Family Inc.
 - 2. Ductmate Industries, Inc.
 - 3. Hardcast, Inc.
 - 4. Nexus PDQ.
 - 5. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Description: Add-on factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. Material: Galvanized steel.
- D. Gage and Shape: Match connecting ductwork.

2.10 DUCT SILENCERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Dynasonics.
 - 2. Industrial Noise Control, Inc.
 - 3. Ruskin Company.
 - 4. Vibro-Acoustics.
- B. General Requirements:
 - 1. Factory fabricated.
 - 2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
 - 3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Shape:
 - 1. Rectangular straight with splitters or baffles.
 - 2. Round straight with center bodies or pods.
 - 3. Rectangular elbow with splitters or baffles.
 - 4. Round elbow with center bodies or pods.
 - 5. Rectangular transitional with splitters or baffles.
- D. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel, 0.034 inch thick.
- E. Round Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel.
 - 1. Sheet Metal Thickness for Units up to 24 Inches in Diameter: 0.034 inch thick.
 - 2. Sheet Metal Thickness for Units 26 through 40 Inches in Diameter: 0.040 inch thick.
 - 3. Sheet Metal Thickness for Units 42 through 52 Inches in Diameter: 0.05 inch thick.
 - 4. Sheet Metal Thickness for Units 54 through 60 Inches in Diameter: 0.064 inch thick.

- F. Inner Casing and Baffles: ASTM A 653/A 653M, G90 galvanized sheet metal, 0.034 inch-thick, and with 1/8-inch-diameter perforations.
- G. Special Construction:
 - 1. Suitable for outdoor use.
 - 2. High transmission loss to achieve STC 45.
 - 3. Silencers installed in aluminum or stainless steel ductwork shall be fabricated from the same type of material,
- H. Connection Sizes: Match connecting ductwork unless otherwise indicated.
- I. Principal Sound-Absorbing Mechanism:
 - 1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
 - 2. Dissipative type with fill material.
 - a. Fill Material: Inert and vermin-proof fibrous material, packed under not less than 5 percent compression
 - b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.
 - 3. Lining: None.
- J. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.
 - 1. Joints: flanged connections.
 - 2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
 - 3. Reinforcement: Cross or trapeze angles for rigid suspension.
- K. Accessories:
 - 1. Factory-installed end caps to prevent contamination during shipping.
 - 2. Removable splitters.
- L. Source Quality Control: Test according to ASTM E 477.
 - 1. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm face velocity.
 - 2. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.
- M. Capacities and Characteristics:
 - 1. Configuration: Straight and 90-degree elbow as indicated on the drawings.
 - 2. Shape: Rectangular and Round as indicated on the drawings.
 - 3. Attenuation Mechanism: Acoustical glass fiber or Acoustical glass fiber with protective film liner as indicated on the drawings.
 - 4. Maximum Pressure Drop including system effects: 0.35-inch wg.
 - 5. Casing:
 - a. Attenuation: Standard or High transmission loss as indicated on the drawings.

- b. Outer Material: Galvanized steel or Aluminum to be of same type of material as connected ductwork.
 - c. Inner Material: Galvanized steel or Aluminum to be of same type of material as connected ductwork.
- 6. End Connection: Flange.
- 7. Length: Refer to drawings.
- 8. Face Dimension: Refer to drawings.
- 9. Face Velocity: Refer to drawings.
- 10. Dynamic Insertion Loss: Refer to drawings.
- 11. Generated Noise: Refer to drawings.
- 12. Accessories:
 - a. Access door.

2.11 TURNING VANES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Aero-Dyne Sound Control Co.
 - 2. CL WARD & Family Inc.
 - 3. Ductmate Industries, Inc.
 - 4. Duro Dyne Inc.
 - 5. Elgen Manufacturing.
 - 6. Hardcast, Inc.
 - 7. METALAIRE, Inc.
 - 8. SEMCO LLC.
 - 9. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
 - 1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
- E. Vane Construction: Single wall for ducts up to 36 inches wide and double wall for larger dimensions.

2.12 REMOTE DAMPER OPERATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Pottorff.
 - 2. Ventfabrics, Inc.
 - 3. Young Regulator Company.

- B. Description: Cable system designed for remote manual damper adjustment.
- C. Tubing: Aluminum.
- D. Cable: Steel.
- E. Wall-Box Mounting: Surface.
- F. Wall-Box Cover-Plate Material: Steel.

2.13 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Aire Technologies.
 - 2. American Warming and Ventilating; a Mestek Architectural Group company.
 - 3. Cesco Products; a division of MESTEK, Inc.
 - 4. CL WARD & Family Inc.
 - 5. Ductmate Industries, Inc.
 - 6. Elgen Manufacturing.
 - 7. Flexmaster U.S.A., Inc.
 - 8. Greenheck Fan Corporation.
 - 9. McGill AirFlow LLC.
 - 10. Nailor Industries Inc.
 - 11. Pottorff.
 - 12. Ventfabrics, Inc.
 - 13. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
 - 1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Vision panel.
 - d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - e. Fabricate doors airtight and suitable for duct pressure class.
 - 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches Square: Continuous and two sash locks.
 - c. Access Doors up to 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.
 - d. Access Doors Larger Than 24 by 48 Inches: Continuous and two compression latches with outside and inside handles.
- C. Provide access doors with fireproof gaskets in kitchen range hood exhaust ductwork. Doors shall be of extra-heavy black iron construction and grease-tight when in place. Locate doors on

20 foot centers on straight runs of ductwork and at each change of direction. Position doors on the side of duct a minimum of 1.5 inches above the bottom of the duct.

- D. Provide access doors with watertight gaskets in [clothes dryer exhaust ductwork. Doors shall be of extra-heavy aluminum construction. Locate doors on 20 foot centers on straight runs of ductwork and at each change in direction. Position doors on the side of duct a minimum of 1.5 inches above the bottom of the duct.

2.14 DUCT ACCESS PANEL ASSEMBLIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. 3M.
 - 2. Ductmate Industries, Inc.
 - 3. Flame Gard, Inc.
- B. Labeled according to UL 1978 by an NRTL.
- C. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.
- D. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.
- E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.
- F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.15 FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CL WARD & Family Inc.
 - 2. Ductmate Industries, Inc.
 - 3. Duro Dyne Inc.
 - 4. Elgen Manufacturing.
 - 5. Hardcast, Inc.
 - 6. JP Lamborn Co.
 - 7. Ventfabrics, Inc.
 - 8. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Materials: Flame-retardant or noncombustible fabrics.
- C. Coatings and Adhesives: Comply with UL 181, Class 1.
- D. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches wide attached to two strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.
- E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26 oz./sq. yd.
 - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.

3. Service Temperature: Minus 40 to plus 200 deg F.
- F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
1. Minimum Weight: 24 oz./sq. yd.
 2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
 3. Service Temperature: Minus 50 to plus 250 deg F.
- G. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
1. Minimum Weight: 16 oz./sq. yd.
 2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
 3. Service Temperature: Minus 67 to plus 500 deg F.
- H. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
1. Minimum Weight: 14 oz./sq. yd.
 2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
 3. Service Temperature: Minus 67 to plus 500 deg F.

2.16 FLEXIBLE DUCTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Flexmaster U.S.A., Inc.
 2. Flex-Tek Group.
 3. JP Lamborn Co.
 4. McGill AirFlow LLC.
 5. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Insulated, Flexible Duct: UL 181, Class 0, interlocking spiral of aluminum foil; fibrous-glass insulation; aluminized vapor-barrier film.
1. Pressure Rating: 8-inch wg positive or negative.
 2. Maximum Air Velocity: 5000 fpm.
 3. Temperature Range: Minus 20 to plus 250 deg F.
 4. Insulation R-value: Comply with ASHRAE/IESNA 90.1
- C. Flexible Duct Connectors:
1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action plus sheet metal screws in sizes 3 through 18 inches, to suit duct size.
 2. Non-Clamp Connectors: Adhesive plus sheet metal screws.
 3. into wall.

2.17 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install test holes at fan inlets and outlets and elsewhere as indicated.
- G. Install fire and smoke dampers according to UL listing.
- H. Connect ducts to duct silencers rigidly to ductwork and with flexible connector when connected directly to equipment.
- I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. Upstream and downstream from duct filters.
 - 3. At outdoor-air intakes and mixed-air plenums.
 - 4. At drain pans and seals.
 - 5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
 - 6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - 7. At each change in direction and at maximum 50-foot spacing.
 - 8. Upstream and downstream from turning vanes.
 - 9. Upstream from duct silencers.
 - 10. Control devices requiring inspection.
 - 11. Elsewhere as indicated.

- J. Install access doors with swing against duct static pressure.
- K. Access Door Sizes:
 - 1. Minimum Size Access: 16 by 12 inches.
 - 2. Where Duct Size does Not permit a 16 by 12 access door: 12 by 10 inches.
- L. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- M. Install flexible connectors to connect ducts to equipment.
- N. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- O. Connect terminal units to supply ducts directly. For connections to motor driven equipment connect with flexible connector.
- P. Connect diffusers or light troffer boots to ducts directly.
- Q. Connect flexible ducts to metal ducts with draw bands plus sheet metal screws.
- R. Install duct test holes where required for testing and balancing purposes.

3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Operate dampers to verify full range of movement.
 - 2. Inspect locations of access doors and verify that purpose of access door can be performed.
 - 3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
 - 4. Inspect turning vanes for proper and secure installation.
 - 5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION

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SECTION 233423

HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Utility set fans.
 - 2. Centrifugal roof ventilators.
 - 3. In-line centrifugal fans.

1.3 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base fan-performance ratings on sea level.
- B. Operating Limits: Classify according to AMCA 99.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:
 - 1. Certified fan performance curves with system operating conditions indicated.
 - 2. Certified fan sound-power ratings.
 - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 4. Material thickness and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
 - 6. Roof curbs.
 - 7. Fan speed controllers.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.
- C. Delegated-Design Submittal: For unit hangars and supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
 1. Roof framing and support members relative to duct penetrations.
 2. Ceiling suspension assembly members.
 3. Size and location of initial access modules for acoustical tile.
 4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Belts: One set for each belt-driven unit.

1.8 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.
- C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.9 COORDINATION

- A. Coordinate size and location of structural-steel support members.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided.
- C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 UTILITY SET FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck Fan Corporation
 - 2. Twin City Fan Companies, Ltd.
 - 3. Loren Cook Company.
- B. Housing: The housings on all fan sizes shall be of continuously welded heavy gauge steel. All interior and exterior surface steel shall be coated with a minimum of 2-4 mils of Polyester Urethane, electrostatically applied and baked. Finish color shall be gray. No uncoated metal fan parts will be allowed.
 - 1. Housing Discharge Arrangement: Adjustable to eight standard positions.
- C. Fan Wheels: Single-width, single inlet; welded to cast-iron or cast-steel hub and spun-steel inlet cone, with hub keyed to shaft.
 - 1. Blade Materials: Steel
 - 2. Blade Type: Open radial.
 - 3. Fan wheel shall be manufactured with continuously welded steel blades and coated with a minimum of 2-4 mils of Polyester Urethane, electrostatically applied and baked. Finish color shall be gray.
- D. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
- E. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L₅₀ of 200,000 hours
 - 1. Extend grease fitting to accessible location outside of unit.
- F. Belt Drives:
 - 1. Factory mounted, with final alignment and belt adjustment made after installation
 - 2. Service Factor Based on Fan Motor Size: 1.5.
 - 3. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - 4. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 - 5. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
- G. Accessories:
 - 1. Inlet and Outlet: Flanged.
 - 2. Companion Flanges: Rolled flanges for duct connections of same material as housing.
 - 3. Backdraft Dampers: Gravity actuated with counterweight and interlocking aluminum blades with felt edges in steel frame installed on fan discharge.
 - 4. Access Door: Gasketed door in scroll with latch-type handles.
 - 5. Scroll Dampers: Single-blade damper installed at fan scroll top with adjustable linkage.
 - 6. Inlet Screens: Removable wire mesh.

7. Drain Connections: NPS 3/4 threaded coupling drain connection installed at lowest point of housing.
8. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.
9. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

2.2 CENTRIFUGAL ROOF VENTILATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Greenheck Fan Corporation
 2. Twin City Fan Companies, Ltd.
 3. Loren Cook Company.
- B. Housing: Removable, galvanized steel, mushroom-domed top; square, one-piece, aluminum base with venturi inlet cone.
 1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector.
 2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
- C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- D. Belt Drives:
 1. Resiliently mounted to housing.
 2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 5. Fan and motor isolated from exhaust airstream.
- E. Accessories:
 1. Variable-Speed Drive. Provide NEMA 3R enclosure for roof mounted VFDs.
 2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
 3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
 4. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
 5. Fans serving kitchen hoods shall be listed per UL 762.
- F. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
 1. Configuration: Built-in cant and mounting flange.
 2. Overall Height: 18 inches.
 3. Vented Curb: Unlined with louvered vents in vertical sides for fans serving grease exhaust.
- G. Capacities and Characteristics:

1. Refer to drawings.

2.3 IN-LINE CENTRIFUGAL FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Greenheck Fan Corporation
 2. Twin City Fan Companies, Ltd.
 3. Loren Cook Company.
- B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- C. Direct-Drive Units: Motor mounted in airstream; factory wired to disconnect switch located on outside of fan housing.
- D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
- F. Accessories:
 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 2. Companion Flanges: For inlet and outlet duct connections.
 3. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
- G. Capacities and Characteristics:
 1. Refer to drawings.

2.4 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.5 SOURCE QUALITY CONTROL

- A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install power ventilators level and plumb.
- B. Equipment Mounting:
 - 1. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Section 077200 "Roof Accessories" for installation of roof curbs.
- D. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1.5 inch. Vibration-control devices are specified in 230548.13 "Vibration Controls for HVAC."
- E. Install units with clearances for service and maintenance.
- F. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 3. Verify that cleaning and adjusting are complete.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 5. Adjust belt tension.
 6. Adjust damper linkages for proper damper operation.
 7. Verify lubrication for bearings and other moving parts.
 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 10. Shut unit down and reconnect automatic temperature-control operators.
 11. Remove and replace malfunctioning units and retest as specified above.
- C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Prepare test and inspection reports.

3.4 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
- D. Replace fan and motor pulleys as required to achieve design airflow.
- E. Lubricate bearings.

END OF SECTION

SECTION 233516

MECHANICAL ENGINE EXHAUST SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Refer to drawing schedules for grille, register and diffusers types and accessories.
- B. Related Requirements:
 - 1. Section 233113 "Metal Ducts" for interconnecting metal ductwork.
 - 2. Section 233423 "HVAC Power Ventilators" for fans.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. System installation, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout Method of attaching hangers to building structure.
- B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Car-mon.
 - 2. Fume-A-Vent.
 - 3. Monoxivent.

2.2 SPRING OPERATED HOSE STORAGE REEL

- A. The hose storage reel frame is to be comprised of formed 12 gauge and 2 x 2 x 1/8 square tubular steel and shall be of welded construction. The hose drum shall be constructed of 16 gauge steel welded to 12 gauge steel end plates, forming an airtight cylinder. The internal assembly, combined with a low resistance inlet, shall provide efficient airflow through the drum.
- B. The flange-mounted flexible hose assembly shall be bolted to the air inlet of specified diameter; draw band connection is unacceptable. The drum shall be supported at one end by a 1" internally gusseted steel shaft through a heavy cast frame platform bearing, and at the other end by a sealed rotating outlet fitting of a lubricious synthetic material. The hose reel must be of sufficient size to accommodate the specified hose. The outlet fitting diameter, hose length, hose diameter, shall be as shown on the plans and specifications.
- C. The hose storage reel is to be fitted with an enclosed spring mechanism with balanced torque characteristics, factory tuned for hose type and length. Ratchet stops are to be provided so that the flexible hose assembly can be partially or completely extended. The reel is to be equipped with a spring-loaded mechanical stop mechanism that limits the number of drum rotations so that it cannot be over extended, and so that it will automatically stop when fully rewound on the drum without stress on the flexible hose assembly.

2.3 SPRING OPERATED HOSE STORAGE REEL

- A. The flexible hose suspension system shall support the flexible hose from overhead when not in use, allowing it to be lowered to the operating level when required..
- B. The lifting device shall be a single spring retractor with ratchet stop and 1/4" steel suspension frame with cast eyelet and heavy-duty snap ring. The retractor shall include a safety chain for field attachment. The retractor shall be capable of lifting at least 25 pounds with 25' of travel.

2.4 FLEXIBLE HOSE

- A. Hose shall be of an abrasion resistant type, constructed of a fire-retardant heat resistant fabric. Hose shall be double layer fabric with abrasion resistant wearstrip. Hose shall withstand exhaust temperatures up to 400°F.

2.5 EXHAUST ADAPTER

- A. The exhaust adapter shall be molded of an advanced resin EPDM compound, having an adjustable over center clamp with tapered aluminum jaws for secure pipe attachment.

2.6 DUAL ASSEMBLY EXHAUST ADAPTER

- A. A dual fitting assembly shall be provided for use with dual exhaust vehicles. The dual fitting assembly shall consist of an EPDM dual fitting, two exhaust hoses, two exhaust adapters, and a stainless-steel tapered nozzle.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. After becoming familiar with all details of the work, verify all dimensions in the field.

3.2 INSTALLATION

- A. Install work as shown and according to the manufacturer's diagrams and recommendations.

END OF SECTION

SECTION 233600

AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Shutoff, single-duct air terminal units.
 - 2. Exhaust single-duct terminal units.
 - 3. Casing liner.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of air terminal unit.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. LEED Submittals:
 - 1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
 - 2. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
- C. Shop Drawings: For air terminal units.
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
 - 4. Hangers and supports, including methods for duct and building attachment and vibration isolation.
- D. Delegated-Design Submittal:
 - 1. Materials, fabrication, assembly, and spacing of hangers and supports.
 - 2. Include design calculations for selecting hangers and supports.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Ceiling suspension assembly members.
 - 2. Size and location of initial access modules for acoustic tile.
 - 3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Instructions for resetting minimum and maximum air volumes.
 - b. Instructions for adjusting software set points.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
- C. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

2.2 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ENVIRO-TEC; by Johnson Controls, Inc.
 - 2. Krueger.
 - 3. Nailor Industries Inc.
 - 4. Price Industries.
 - 5. Titus.
- B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.
- C. Casing: 0.040-inch-thick galvanized steel, single wall.
 - 1. Casing Liner: Comply with requirements in "Casing Liner" Article for Fibrous-glass duct liner.

2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 3. Air Outlet: S-slip and drive connections.
 4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Flow Sensor: The unit inlet shall be equipped with a cross-shaped flow sensor with a minimum of one pick-up for each 2-1/2 inch of inlet diameter with amplifying pressure pickup points connected to central averaging chambers. The sensor shall amplify the duct velocity pressure by a factor of 1.75 and shall maintain control accuracy with the same size inlet duct in any configuration. All sensor tubing shall be UL listed fire retardant (FR) type. The assembly shall incorporate an amplified non-directional flow sensor. The pneumatic consumption for the operation of the device shall not exceed 0.012 scfm at 20 psi.
- E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
 2. Damper Position: Normally open.
 3. Shaft: Rust-proof Delrin, Nylon, or PTFE, self lubricating bearings
- F. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.
1. SCR controlled.
 2. Access door interlocked disconnect switch.
 3. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable).
 4. Nickel chrome 80/20 heating elements.
 5. Airflow switch for proof of airflow.
 6. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
- G. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.
1. Control Transformer: Provide stepdown transformer for control voltage. Refer to drawings for source power characteristics. Where multiple VAV shut-off terminals are located within proximity, a centralized transformer shall be located strategically to feed multiple VAVs. Coordinate the transformer location(s) with the electrical contractor and as required for access with the ceiling finishes.
 2. Disconnect Switch: Factory-mounted, fuse type (for VAV shut-off terminals with reheat coils).
 3. Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
 4. The DDC controller shall be furnished by the ATC Contractor for field installation.
 5. The DDC actuator shall be furnished, and factory mounted by the assembly manufacturer and shall be compatible with controls specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
- H. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

- I. Direct Digital Controls: Single-package unitary controller and actuator specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

2.3 EXHAUST SINGLE-DUCT TERMINAL

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Krueger.
 - 2. Nailor Industries Inc.
 - 3. Price Industries.
 - 4. Titus.
- B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.
- C. Casing: 0.034-inch-thick galvanized steel, single wall. Casing includes removable aluminum linear grille and plenum.
 - 1. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 - 2. Air Outlet: S-slip and drive connections.
 - 3. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
 - 4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Flow Sensor: The unit inlet shall be equipped with a cross-shaped flow sensor with a minimum of one pick-up for each 2-1/2 inch of inlet diameter with amplifying pressure pickup points connected to central averaging chambers. The sensor shall amplify the duct velocity pressure by a factor of 1.75 and shall maintain control accuracy with the same size inlet duct in any configuration. All sensor tubing shall be UL listed fire retardant (FR) type. The assembly shall incorporate an amplified non-directional flow sensor. The pneumatic consumption for the operation of the device shall not exceed 0.012 scfm at 20 psi.
- E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
 - 1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
 - 2. Damper Position: Normally open.
- F. Factory-Mounted and -Wired Controls:
 - 1. Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
 - 2. The DDC controller shall be furnished by the ATC Contractor for field installation.
 - 3. The DDC actuator shall be furnished, and factory mounted by the assembly manufacturer and shall be compatible with controls specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
- G. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.
- H. Direct Digital Controls: Single-package unitary controller and actuator specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

2.4 CASING LINER

- A. Casing Liner: Fibrous-glass duct liner, complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
1. Minimum Thickness: 3/4 inch.
 - a. Maximum Thermal Conductivity:
 - 1) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
 2. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 3. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
 - a. Adhesive VOC Content: 80 g/L or less.
 - b. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

2.5 SOURCE QUALITY CONTROL

- A. Factory Tests: Test assembled air terminal units according to AHRI 880.
1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and AHRI certification seal.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports" and with Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
1. Where practical, install concrete inserts before placing concrete.
 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches thick.
 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.
 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hangers Exposed to View: Threaded rod and angle or channel supports.

- D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.2 TERMINAL UNIT INSTALLATION

- A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."
- B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.
- C. Install wall-mounted thermostats.

3.3 CONNECTIONS

- A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.
- B. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.
- C. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

3.4 IDENTIFICATION

- A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
 - 2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Air terminal unit will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.

3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION

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SECTION 233713

GRILLES, REGISTERS AND DIFFUSERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Refer to drawing schedules for grille, register and diffusers types and accessories.
- B. Related Requirements:
 - 1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - 2. Grille and Diffuser Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
- B. Samples: For each exposed product and for each color and texture specified. Actual size of smallest diffuser indicated.
- C. Samples for Initial Selection: For diffusers with factory-applied color finishes. Actual size of smallest diffuser indicated.
- D. Samples for Verification: For diffusers, in manufacturer's standard sizes to verify color selected. Actual size of smallest diffuser indicated.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Ceiling suspension assembly members.
 - 2. Method of attaching hangers to building structure.
 - 3. Size and location of initial access modules for acoustical tile.
 - 4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
 - 5. Duct access panels.
- B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 GRILLES REGISTERS AND DIFFUSERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Krueger.
 - 2. Nailor Industries Inc.
 - 3. Price Industries.
 - 4. Titus.
 - 5. Tuttle & Bailey.
- B. Provide all registers, grilles, diffusers, and linear diffusers (RGD's) of size and type shown on the drawings and as specified hereinafter, suitable for installation in the pertinent surface or structure with plaster frames provided where re- quired. Right is reserved to vary dimensions and locations of air devices to a very reasonable extent, as the work progresses with final locations as deter- mined by Owner. Curved surfaces shall have curved units. Refer to architectural plans.
- C. Unless specifically mentioned otherwise, diffusers, registers and grilles shall be constructed of steel or aluminum. All exhaust devices shall be aluminum. Linear diffusers shall be extruded aluminum.
- D. Finish shall be off white enamel paint unless otherwise noted on the drawings or herein.
- E. Finish shall be a custom color selected by architect for grilles, registers and diffusers connect to the following systems or located in the following areas:
 - 1. AHU-8
 - 2. AHU-9
 - 3. AHU-10
 - 4. FCU-15-13
 - 5. FCU-19-1
 - 6. FCU-19-2
 - 7. FCU-19-3
 - 8. FCU-19-5
 - 9. VAV-1B-11 (Corridor B114)
 - 10. Restaurant B113
 - 11. Cosmetology B120 and B121
- F. All outlets and inlets shall be compatible with the ceiling and wall type shown on the Architectural Plans. Make special note to ensure that outlet/inlet frame is flush with ceiling or wall surface.

2.2 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas where diffusers are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install grilles, registers and diffusers level and plumb.
- B. Outlets and Inlets Locations: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install grilles, registers and diffusers with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

- A. After installation, adjust grilles, registers and diffusers to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

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Bala Project No. 60-20-409

Northeast Metropolitan Regional Vocational High School

Wakefield, MA

SECTION 237223.19

PACKAGED INDOOR FIXED PLATE ENERGY RECOVERY UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Fixed-plate, total heat exchangers in packaged, indoor, energy-recovery units.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include packaged, indoor, fixed-plate, energy-recovery unit rated capacities, operating characteristics, furnished specialties, and accessories.
 - 2. Fans:
 - a. Certified fan-performance curves with system operating conditions indicated.
 - b. Certified fan-sound power ratings.
 - c. Fan construction and accessories.
 - d. Motor ratings, electrical characteristics, and motor accessories.
- B. Shop Drawings: For packaged, indoor, fixed-plate, energy-recovery units.
 - 1. Include plans, elevations, sections, details, and mounting details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
 - 4. Sound power data by octave band for all openings and radiated through the cabinet.
 - 5. Electrical schematics including field wiring connections.
 - 6. Control point schematic and complete written sequence of operation.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, elevations, and other details, drawn to scale. and coordinated with each other, using input from installers of the items involved.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filters: One set of each type of filter specified.
 - 2. Fan Belts: One set of belts for each belt-driven fan in energy recovery units.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of packaged, indoor, fixed-plate, energy-recovery units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Fixed-Plate Total Heat Exchangers: 2 years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- B. ASHRAE Compliance:
 - 1. Applicable requirements in ASHRAE 62.1.
 - 2. Capacity ratings for fixed-plate energy-recovery units shall comply with ASHRAE 84.
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
- D. UL Compliance:
 - 1. Packaged heat-recovery ventilators shall comply with requirements in UL 1812 or UL 1815.
 - 2. Electric coils shall comply with requirements in UL 1995.
- E. Comply with ASTM E84 or UL 723.

2.2 CAPACITIES AND CHARACTERISTICS

- A. Type: Fixed-plate total energy-recovery unit.
- B. Minimum Efficiency Reporting Value:
 - 1. MERV Rating: MERV 13 according to ASHRAE 52.2 for outdoor airstream.
 - 2. MERV Rating: MERV 8 according to ASHRAE 52.2 for exhaust airstream.
- C. Refer to drawings for additional capacity and characteristic requirements.

2.3 PACKAGED, INDOOR, FIXED-PLATE TOTAL ENERGY RECOVERY UNITS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Oxygen8.
 2. Ventacity.
 3. Aldes.
- B. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, gasketed, hinged access doors for inspection and access to internal parts, minimum 1-inch thick, R-6.5, thermal insulation, knockouts for electrical connections, exterior drain connection, and lifting lugs.
- D. Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than 65,000 A.
- E. Fixed-Plate Total Heat Exchanger:
1. Casing: Galvanized steel
 2. Plates: Evenly spaced and sealed and arranged for counter-flow.
 - a. Plate Material: Chemically treated paper or polymer membrane with selective hygroscopicity and moisture permeability, and gas barrier properties.
 3. Bypass Plenum: Within casing, with gasketed face-and-bypass dampers having operating rods extended outside casing.
- F. Supply and Exhaust Fans: Factory mounted and balanced mixed flow plenum type with direct drive motor.
1. Motor and Drive: Direct driven, permanent magnet, synchronous motor type with integral digital motor controller.
 2. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 4. Fan bearings shall be serviceable types with an L-10 life of 40,000 hours.
- G. Filters:
1. Description: Pleated factory-fabricated, self-supported, disposable air filters with holding frames.
 2. UL Compliance: Comply with UL 900.
 3. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.
 4. Filter Media Frame: Beverage board with perforated metal retainer, or metal grid, on outlet side.
 5. Filter Mounting Frames: Arranged with access doors or panels on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
 6. Provide factory mounted pressure sensors to measure filter pressure drop across filters. Pressure drop shall be digital feedback to controller for utilization in control and alarm sequencing. Unit controller shall monitor filter pressure level and report when filter changes are required.
- H. Electric Preheat Coil

1. Provide open coil electric heaters of the size, capacity and performance shown in the equipment schedules.
2. All duct heaters shall be tested and certified to UL and CSA.
3. Frame to be corrosion-resistant and made of galvanized steel.
4. Coils shall be made of high-grade Nickel-Chrome alloy and shall be insulated from the frame by means of non-rotating ceramic bushings.
5. Heater to come with door mounted disconnect switch and air proving switch.
6. Provide SCR control that modulates the heater and supplies the exact amount of power to match the demand. Input signal shall be 0-10V.
7. Heaters shall be equipped with a fail-safe automatic reset disc-type thermal cut-out located in the top frame component above the heating element.

2.4 CONTROLS

- A. Control Panel: Solid-state, programmable, microprocessor-based control unit factory installed in controls cabinet. Integrate to BACnet, as specified in Section 230923 "Direct Digital Control (DDC) System for HVAC".
- B. All unit controls shall operate off a transformer from the main power supply for single point power connection. All internal controls and sensors shall be factory prewired and tested. The microprocessor shall have dual Ethernet ports with an internal firewall to allow remote access via third party without compromising the clients internal Network.
- C. Frost Control: Unit controller shall operate preheat coil to maximize heat transfer without frosting. Energy recovery device shall be installed over a stainless-steel double sloped condensate pan.
- D. Include with each unit touch pad type human interface that allows monitoring and control of all unit functions. Human interface shall communicate with unit controller by hardwire connection. Human interface shall be unit mounted.
- E. The control system will regulate temperatures, airflows and other functions as required. Unit controller shall be pre-programmed with factory tested software for all possible functions.
- F. The controller shall provide the following, refer to Section 230923 "Direct Digital Control (DDC) System for HVAC" for specific unit control sequences:
 1. Control of fans correcting for both changes in total static pressure and air density in both VAV and constant airflow applications
 2. Fan performance monitoring
 3. Ventilation airflow monitoring and control
 4. Frost protection
 5. Monitoring alarms, faults and maintenance points including filter changeout
 6. Time and date schedules
 7. Data logging and trending
- G. Provide unit mounted non-fused disconnect switches with power connection for electric heating coil and connection for remainder of unit.
- H. Supply all necessary temperature and pressure sensors complete with plug in wiring harnesses for proper operation of unit.
- I. Enthalpy sensor.

- J. Dirty filter switch.
- K. Low-Voltage Transformer: Integral transformer to provide control voltage to unit from primary incoming electrical service.
- L. Electric Coil Controls:
 - 1. Factory-mounted sensor in outside-air intake with sensor adjustment located in control panel to control electric coil and maintain minimum entering temperature, to avoid frost formation.

2.5 SOURCE QUALITY CONTROL

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. AHRI Compliance: Capacity ratings for air-to-air energy-recovery equipment certified as complying with AHRI 1060 (AHRI 1061).
- C. Fan Performance Rating: Comply with AMCA 211 and label fans with AMCA-certified rating seal. Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency according to AMCA 210/ASHRAE 51.
- D. Fan Sound Ratings: Comply with AMCA 301 or AHRI 260 (IP). Air-handling unit fan sound ratings shall comply with AMCA 301 or AHRI 260 (IP).
- E. UL Compliance:
 - 1. Packaged fixed plate energy recovery units shall comply with requirements in UL 1812; or UL 1815.
 - 2. Electric Coils: Comply with UL 1995.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media before packaged, indoor, fixed-plate, energy-recovery unit installation. Replace with new insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install packaged, indoor, fixed-plate, energy-recovery units, so supply and exhaust airstreams flow in opposite directions.
 - 1. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to interior components.
 - 2. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.

3. Access doors and panels are specified in Section 233300 "Air Duct Accessories."

- B. Suspended Units: Suspend units from structural-steel support frame, using threaded steel rods and spring hangers. Comply with requirements for vibration-isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Install units with clearances for service and maintenance.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

3.3 DUCTWORK CONNECTIONS

- A. Comply with requirements for ductwork according to Section 233113 "Metal Ducts."
- B. Connect duct to units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.4 ELECTRICAL CONNECTIONS

- A. Install electrical devices furnished with units but not factory mounted.
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Section 230923 "Direct Digital Control (DDC) System for HVAC."

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections with the assistance of a factory-authorized service representative.
- D. Tests and Inspections:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

- E. Packaged, indoor, fixed-plate, energy-recovery units will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.7 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.

3.8 ADJUSTING

- A. Adjust moving parts to function smoothly and lubricate as recommended by manufacturer.
- B. Adjust initial temperature and humidity setpoints.
- C. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy-recovery units.

END OF SECTION

SECTION 237343.19

OUTDOOR AND INDOOR, CUSTOM AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Outdoor and indoor, custom air-handling units.

1.2 ACTION SUBMITTALS

- A. Product Data: For each outdoor and indoor, custom air-handling unit.
1. Product information organized to show compliance with each performance requirement of "Performance Requirements" article.
 2. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 3. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 4. Include unit dimensions and weight.
 5. Include cabinet material, metal thickness, finishes, insulation, and accessories.
 6. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated. For fans operating at variable speeds include curves in 10 percent speed increments starting at design speed down to minimum speed.
 - b. Include fan-sound power ratings in all eight octave bands. Include inlet or outlet sound power levels to coincide with sound requirements indicated on Drawings.
 - c. Include fan construction and accessories. Submit sufficient information to show product compliance with requirements indicated.
 - d. Include dimensions and weight.
 - e. Include motor ratings, electrical characteristics, and motor accessories.
 7. Vibration isolation product data with performance ratings. Uniquely identify and include information for each different isolator type and indicate for each air-handling unit where each isolator type is being used.
 8. Include certified coil-performance ratings with system operating conditions indicated. Product data to include: dimensions, dry and operating weight, volume of fluid contained, materials of construction, and performance ratings with system operating conditions indicated.
 9. Casing insulation product data and performance ratings.
 10. Access door and access panel product data and performance ratings.
 11. Roofing product data and performance ratings.
 12. Louver product data and performance ratings.
 13. Paint product data and performance ratings.
 14. Electrical product data and performance ratings.
 15. Metal grating product data and performance ratings.
 16. Electric heater product data with performance ratings.
 17. Dampers product data, including housings, linkages, and operators with performance ratings.
 18. Filters product data with performance characteristics.

19. Heat wheels product data with performance ratings.
20. Fixed plate heat exchangers product data with performance ratings.
21. Pipe insulation and jacket product data.
22. Roof curbs product data.

B. Shop Drawings: For each type and configuration of indoor, custom air-handling unit.

1. Prepared by manufacturer's factory employees with review and sign-off by those individuals responsible for manufacturing the air-handling units.
2. Include plans, elevations, sections, and mounting details..
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, methods of field assembly, components, and location and size of each field connection.
4. Detail fabrication and assembly of indoor, custom air-handling units, as well as procedures and diagrams.
5. Indicate details of construction with materials description including applicable specified standards and material grades in sufficient detail for reviewers to evaluate point by point compliance with requirements indicated for each air-handling unit.
6. Use actual dimensions of internal equipment in preparing Shop Drawings. Identify mechanical equipment shown on Shop Drawings with equipment designations on Drawings.
7. Thickness and finish of all casing materials with cross references indicated where each is used. Uniquely identify and include information for each different casing construction.
8. Details for each unique casing joint and reinforcing. Indicate wall joints, wall to floor joints, wall to roof joints, floor joints, and roof joints.
9. Roofing details.
10. Assembly details of base and casing for units consisting of multiple sections requiring field assembly.
11. Sizes and dimensioned locations of field connections for ductwork, piping, electrical, and controls.
12. Base and casing penetration and sealing details for factory-installed conduit.
13. Base and casing penetration and sealing details for factory-installed piping including coils.
14. Details of casing connections to field-installed ductwork.
15. Size, shape and layout of base members including localized support of internal components.
16. Base materials, thickness, finishes, lifting provisions, and mounting requirements. Uniquely identify and include information for each different base construction. Clearly indicate for each air-handling unit.
17. Recommended points of field attachment with dimensioned locations.
18. Size and location of each access door, including clearing opening size, with door swing indicated.
19. Size and location of each access panel with service equipment superimposed to show relationship of panel to internal equipment.
20. Drain pans and associated piping, with sizes and locations dimensioned, including relationship to internal equipment.
21. Floor drains and associated piping, with sizes and locations dimensioned, including relation to internal equipment.
22. Coil framework and support including enlarged details showing framework attachment to air-handling unit base, coil attachment to framework, and means for individual coil removal.
23. Mounting details of all internal components, such as fans, filters, and dampers.
24. Hoist rails layout for internal equipment showing size of members, attachments to structure, and serviced equipment superimposed to indicate relationships.
25. Location of receptacles, service lights, and switches.

26. Location of motor controllers and disconnect switches.
27. Size and location of junction boxes used for interface with field electrical power.
28. Point-to-point electrical power wiring diagrams including wire size, conduit size, motor controllers sizes, switch types and ratings, receptacle types and ratings, service light fixture types and ratings.
29. Point-to-point control wiring diagrams including cable types and sizes, conduit sizes, and connected control devices.
30. Control panel drawings drawn to scale showing detailed internal layout.
31. Indicate code, operating, and maintenance clearances drawn to scale using dashed lines.
32. Indicate weights of internal components, weight of each separately shipped section, and air-handling unit total weight.
33. VRF EEV and AHU Kit mounting details

C. Comparison Schedule:

1. Submit a schedule to indicate performance of equipment scheduled on Drawings directly compared to performance of submitted equipment.
2. Clearly identify each line in schedule to indicate "Scheduled" where indicating performance scheduled on Drawings and "Submitted" where indicating performance of submitted equipment.
3. Organize schedule to first indicate performance scheduled on Drawings on one line followed by line directly below that indicates performance of submitted equipment.
4. Comparison schedule shall follow arrangement and organization of scheduled information indicated on Drawings.
5. Submitted equipment shall have a value for each scheduled value indicated.

D. Delegated Design Submittals: For vibration isolation indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, sections, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.
- B. Source quality-control reports.
- C. Startup service reports.
- D. Field quality-control reports.
- E. Sample Warranty: For manufacturer's warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Cartridge Filters: One set for each air-handling unit.

2. Panel Filters: One set for each air-handling unit.
3. Heat Wheel Belts: One set for each heat wheel with belt-drive assembly.

- B. Tool Kit: Manufacturer to provide a tool kit including special tools required for air-handling unit service. See "Accessories" Article for additional requirements.

1.6 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

1.7 DELIVERY, STORAGE, HANDLING

- A. Deliver air-handling units with factory-installed shipping skids and lifting lugs; pack small components in factory-fabricated protective containers. Cover units with heat-shrinkable plastic sheeting suitable for shipping from point of manufacture to Project.
- B. Handle air-handling units carefully to avoid damage to components, casing, and finish. Do not install damaged components; replace and return damaged components to air-handling unit manufacturer.
- C. Store air-handling units in a clean dry place and protect them from weather and construction activities.
- D. Keep air-handling units fully covered and protected during construction. Remove dirt and debris and clean units to a factory-cleaned condition.
- E. Comply with manufacturer's written rigging and installation instructions for unloading air-handling units and moving them to their final locations.
- F. For air-handling units equipped with key locks on access doors, keep doors locked during construction.
1. If access is required within air-handling units, only open the doors to sections that require access and lock doors at the end of each work shift.
 2. Protect inside of air-handling units from damage and keep inside of units as clean as the factory-cleaned condition.
 3. Report observed abuse to Construction Manager for immediate corrective action.

1.8 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of air-handling units that fails in materials or workmanship within specified warranty period.
1. Warranty Period: 5 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design air-handling units, vibration isolation, including comprehensive engineering analysis, using performance requirements and design criteria indicated.
- F. Casing Structural Performance:
 - 1. Floor: Capable of withstanding positive/negative 8 inches wg of internal static pressure, without exceeding a deflection of L/300 of span.
 - 2. Walls and Roof: Capable of withstanding positive/negative 8 inches wg of internal static pressure, without exceeding a midpoint deflection of L/200 of span.
- G. Casing Leakage Performance: Comply with more stringent of the following requirements:
 - 1. ASHRAE 111, Class 3 leakage or better at[plus or minus 8 inches wg.
 - 2. Not more than 0.5 percent of the total unit airflow at 8 inches wg.
- H. Casing Thermal Performance:
 - 1. Surface Condensation: Air-handling manufacturer shall evaluate potential for condensation and design and manufacture entire unit casing to prevent condensation at most extreme operating conditions encountered.
 - 2. Thermal Break: Incorporate a thermal break at each through metal path to prevent condensation from occurring on interior and exterior of casing.
 - 3. U-Value: Overall U-value or equivalent R-value of casing shall not exceed governing codes and ASHRAE/IES 90.1 while considering the effects of metal-to-metal contact and thermal bridging in calculations.
- I. Air Tunnel Aerodynamic Performance: Position air-handling unit internal components and transition between internal components to maintain uniform airflow; minimize sound levels and energy consumption. Use methods indicated and other means to ensure compliance.
 - 1. Use turning vanes if necessary to direct the air path.
 - a. Design, manufacture, and install vanes in accordance with applicable requirements in ASHRAE and SMACNA guidelines, handbooks, and standards.
 - b. Install vanes firmly in place so that no vane movement occurs at worst-case airflow capacity possible.
 - 2. Use fan inlet and discharge transitions and other devices to maximize system regain and minimize airborne sound levels.
 - 3. Center system components such as coils, fans, and filters, vertically and horizontally, in the airstream.

4. Maintain spacing between components such that airflow patterns to adjacent components are as uniform as possible and that component "dead spots" or "jetted areas" are avoided.
 5. Design and install internal structural supports, piping, and conduit that do not block airflow and impede performance of coils, fans, filters, and other unit components, and service space clearances.
- J. Air-Handling Unit Acoustical Performance: Noise from air-handling unit casing and openings not ducted shall not exceed following sound power levels. Sound power levels indicated in each octave band are in decibels (dB) (reference 1 pW).

1. MAU-1

Opening	63	125	250	500	1000	2000	4000	8000
Discharge	82	80	97	92	89	86	82	78
Inlet	80	76	93	85	72	68	61	53
Outside	77	74	91	82	69	66	59	51
Exhaust	0	0	0	0	0	0	0	0
Casing Radiated	75	68	82	71	71	56	48	41

2. MAU-2

Opening	63	125	250	500	1000	2000	4000	8000
Discharge	87	93	106	98	94	90	85	83
Inlet	85	100	101	88	80	79	77	77
Outside	81	93	95	85	78	74	73	73
Exhaust	0	0	0	0	0	0	0	0
Casing Radiated	76	82	87	73	73	57	48	43

3. RTU-1

Opening	63	125	250	500	1000	2000	4000	8000
Discharge	77	74	74	86	81	80	77	74
Inlet	71	69	68	77	64	55	50	44
Outside	72	68	71	82	75	73	69	64
Exhaust	72	71	74	82	68	63	63	62
Casing Radiated	72	66	63	70	68	54	46	39

4. RTU-2

Opening	63	125	250	500	1000	2000	4000	8000
Discharge	84	82	83	97	90	88	87	85
Inlet	76	74	72	89	71	63	59	52
Outside	77	76	78	90	82	80	78	74
Exhaust	74	73	78	91	73	71	71	70
Casing Radiated	76	71	69	79	75	60	54	49

5. HRU-1

6. HRU-2

7. HRU-3

8. HRU-4

Opening	63	125	250	500	1000	2000	4000	8000
Discharge	86	84	93	100	92	89	86	82
Inlet	80	77	84	93	70	67	60	51
Outside	81	79	90	95	85	82	78	73
Exhaust	83	81	93	99	78	77	75	73
Casing Radiated	79	73	79	83	76	61	53	46

9. HRU-5

10. AHU-1

Opening	63	125	250	500	1000	2000	4000	8000
Discharge	94	89	96	92	90	85	83	82
Inlet	87	92	100	87	83	81	80	79
Outside	89	88	96	89	85	80	78	77
Exhaust	91	89	95	92	88	83	82	80
Casing Radiated	83	77	76	62	55	51	41	31

11. AHU-2

Opening	63	125	250	500	1000	2000	4000	8000
Discharge	85	85	101	93	89	86	86	82
Inlet	83	83	100	87	80	79	80	78
Outside	78	78	91	83	80	76	77	76
Exhaust	80	80	93	86	83	80	80	80
Casing Radiated	80	75	87	73	75	59	54	49

12. AHU-3

Opening	63	125	250	500	1000	2000	4000	8000
Discharge	91	90	106	96	93	89	87	83
Inlet	87	90	105	87	81	80	79	75
Outside	84	86	96	85	80	77	75	72
Exhaust	84	87	97	87	83	80	78	74
Casing Radiated	83	80	91	75	76	60	53	47

13. AHU-4

Opening	63	125	250	500	1000	2000	4000	8000
Discharge	89	84	91	89	87	83	81	80
Inlet	78	83	91	80	76	74	73	72
Outside	82	79	85	81	78	74	72	71
Exhaust	85	81	87	83	81	78	76	73
Casing Radiated	77	70	68	57	52	48	38	28

14. AHU-5

Opening	63	125	250	500	1000	2000	4000	8000
Discharge	91	85	86	89	89	85	82	81
Inlet	80	77	87	81	74	73	72	71
Outside	84	79	82	85	78	74	71	70
Exhaust	85	80	83	81	80	78	75	73
Casing Radiated	79	70	64	62	53	50	39	29

15. AHU-6

Opening	63	125	250	500	1000	2000	4000	8000
Discharge	90	84	84	89	87	84	81	80
Inlet	82	79	84	92	81	78	77	77
Outside	85	80	82	88	83	78	76	76
Exhaust	87	82	82	88	86	83	80	79
Casing Radiated	80	71	63	64	54	51	40	30

16. AHU-7

Opening	63	125	250	500	1000	2000	4000	8000
Discharge	89	83	89	86	85	82	79	78
Inlet	79	80	92	81	76	75	75	73
Outside	83	79	88	81	79	75	73	72
Exhaust	85	80	87	83	82	79	77	75

Casing Radiated	78	70	70	57	50	48	38	28
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17. AHU-8

Opening	63	125	250	500	1000	2000	4000	8000
Discharge	89	88	105	97	94	91	90	88
Inlet	81	79	94	82	69	66	61	52
Outside	84	86	97	91	88	84	80	75
Exhaust	83	85	102	91	78	76	75	73
Casing Radiated	79	76	82	67	58	55	46	35

18. AHU-9

Opening	63	125	250	500	1000	2000	4000	8000
Discharge Rear	87	85	102	95	91	88	87	86
Discharge Right	86	84	101	94	90	87	86	85
Outside	81	79	94	83	70	67	63	56
Exhaust	85	83	91	99	90	87	83	78
Return	86	84	93	102	82	81	79	76
Casing Radiated	81	75	81	74	60	58	48	37

19. AHU-10

Opening	63	125	250	500	1000	2000	4000	8000
Discharge Rear	86	85	102	94	91	87	87	84
Discharge Right	81	79	96	88	85	82	81	78
Outside	78	75	89	78	67	62	54	43
Exhaust	85	84	101	92	88	84	83	81
Return	85	84	101	89	79	78	79	77
Casing Radiated	80	74	82	67	59	56	48	38

K. Outdoor Environment:

1. Air-handling units specially designed to withstand effects of wind, rain, ice, snow, air quality, sun, and other influences associated with outdoor installations.
2. Comply with requirements of air-handling unit and governing codes.

L. Safety:

1. Comply with OSHA regulations.
2. Exposed sharp edges and corners of metal shall be protected or rounded to prevent injury to personnel not wearing gloves.
3. Cover exposed ends of screws with plastic or metal covers to prevent injury to personnel coming in contact with screws.

M. Serviceability:

1. Hoisting Provisions: Fans and motors weighing more than 200 lb shall have full-length hoist rails mounted over the equipment to facilitate service, removal, and replacement.
2. Mounting Location: Install internal components in readily accessible locations to facilitate ease of service and replacement.
3. Service Access:
 - a. Internal components shall be serviceable through access sections with doors indicated on Drawings.
 - b. Internal components shall be removable and replaceable through access doors or panels.

- c. Review requirements for access doors and panels indicated and recommend additional access doors and panels if required for uninhabited service, removal, and replacement of components.
- 4. Tripping Hazards: Floors in accessible sections of air-handling unit shall be free of standing seams, reinforcing, supports, or section splits located in the walking path that is capable of causing a tripping hazard. Locate section splits immediately adjacent to internal walls.
- N. Quality: Type and thickness of materials indicated are the minimum acceptable. Provide better-quality materials of a heavier thickness if required to comply with performance requirements indicated.
 - 1. If manufacturer's standard construction exceeds requirements indicated, use manufacturer's standard construction.
 - 2. If manufacturer's standard construction does not comply with requirements indicated, modify manufacturer's standard construction to comply with requirements.
- O. Vibration Performance: Air-handling unit manufacturer shall evaluate vibration of internal components installed inside of air-handling units and include internal vibration isolation required to limit the vibration transmitted to the building at a low enough level that vibration is not perceived by building occupants.

2.2 CAPACITIES AND CHARACTERISTICS

- A. See equipment schedules on Drawings.

2.3 SOURCE LIMITATIONS

- A. Source all outdoor custom air-handling units from same manufacturer.
- B. Like components furnished with air-handling units shall be from same manufacturer.
- C. Air-handling units shall be manufactured in United States or Canada

2.4 OUTDOOR, CUSTOM AIR-HANDLING UNITS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Johnson Controls Custom
 - 2. Trane Custom
 - 3. Haakon

2.5 UNIT ARRANGEMENT AND CONFIGURATION

- A. Arrangement: Project-specific arrangement and configuration of air-handling units indicated on Drawings. Do not deviate from requirements indicated without submitting a formal request clearly describing each deviation and reason for each deviation, and only after receiving Architect's written acceptance.
- B. Mounting Requirements: Units mounted on vibration isolation roof curbs.

- C. Multiple Sections, Splits: Air-handling unit manufacturer to determine number of sections and location of section splits required for each air-handling unit in accordance with the following criteria:
1. Physical size and weight of each section, on-site path of travel, and methods for erection and installation. Air-handling manufacturer to review criteria with Installer before preparing Shop Drawings.
 2. Maximize physical size of each air-handling unit section considering, shipping, moving, erecting, and installation.
 3. Minimize the number of air-handling unit sections requiring field assembly. Preference is for single-piece air-handling units where possible.

2.6 AIR-HANDLING UNIT BASE

A. Performance:

1. Air-handling unit manufacturer shall design and assemble air-handling unit casing and internal components for attachment and support by air-handling unit structural base.
2. Design air-handling units to be lifted from only the air-handling unit structural base and not the casing.
3. Support air-handling units from only the perimeter base unless otherwise indicated on Drawings.
4. Air-handling unit manufacturer to size and locate intermediate structural base supports as required to comply with structural performance indicated for air-handling unit floors.
5. Level base before factory assembly of air-handling unit casing and internal components to ensure proper fit and alignment.

B. Structural Member Size:

1. Air-handling unit manufacturer shall select size of base members and construction of base to withstand the rigors of loading, unloading, shipping, and rigging without damage to air-handling unit components or misalignment of factory-assembled components.
2. Depth and weight of structural members shall be selected by air-handling unit manufacturer to comply with performance requirements indicated.
3. Depth of perimeter base members is not less than 6 inches deep.

C. Structural Member Spacing: Positioned as required to comply with requirements indicated, but not to exceed 24 inches

D. Materials: Structural carbon steel, ASTM A36/A36M

1. Perimeter Members: Angle, channel, I or W beam shapes, or tube.
2. Intermediate Members (Spanning Full Width of Unit): Angle, channel, I or W beam shapes or tube.
3. Cross Members (Spanning Intermediate Members): Angle, channel, or, tube.

E. Carbon-Steel Finish, Mill Galvanized: Mill-galvanized carbon steel with weld-damaged areas cleaned, prepared, and painted with galvanized paint after fabrication.

F. Carbon-Steel Finish: Carbon-steel bases shall be shot-blasted, cleaned, prepared, and hot-dip galvanized after fabrication.

G. Welding Filler Metals: Comply with AWS welding codes for welding materials appropriate for thickness and chemical analysis of material being welded.

1. Use welding materials with corrosion properties equal to material being welded.

Unit base shall be primed and finished with rust inhibiting epoxy paint. Color shall be industrial Grey.

H. Welding Procedures:

1. Structural Welding Codes: AWS D1.1/D1.1M for carbon steel
2. Join structural members to one another using continuous welds.
3. After welding and fabrication, deburr and grind exposed welds to provide smooth surfaces free of sharp edges.

I. Penetrations through Base Perimeter: Seal pipe, tubing, and conduit penetrations through base perimeter members to provide a watertight assembly.

J. Section Joints: Air-handling units consisting of multiple sections for field assembly shall be joined with structural joining plates.

1. Joining plate material type to match base.
2. Joining plate of thickness required to join sections without resulting in a permanent deflection, minimum 1/2 inch thick.
3. Continuously weld joining plates to each mating end of base.
4. Joining plates shall not extend beyond outer edge of adjoining base.
5. Plates to include at least three equally spaced holes for field connection using factory-furnished threaded hardware of a nominal diameter of at least 1/2 inch.

K. Lifting Provisions: Air-handling unit manufacturer to design and install lifting lugs of size and location required to comply with performance requirements indicated. Lifting lugs extending beyond the base shall be easily removable in the field after unit is installed.

L. Curb Cap:

1. For air-handling units installed on a continuous perimeter curb, provide air-handling unit base with a continuous structural angle counterflashing.
2. Angle shall extend down vertical face of curb to completely cover wood nailer.
3. Coordinate inside dimension of angle counterflashing with curb dimension and roofing. Provide adequate clearance between angle counterflashing and roofing over curb.

2.7 UNIT CASINGS

A. Casing Assembly:

1. Dissimilar Metals: Isolate dissimilar metals that are in contact to prevent galvanic action and corrosion.
2. Framing and Supports: Interconnect and support individual casing wall and roof panels using either formed panel construction or framed construction with structural support members. For framed casing construction, materials used to construct casing of structural support members shall be as follows:
 - a. Casings with Aluminum Outer and Inner Skins: Aluminum extrusions in accordance with ASTM B211 Alloy 6063 T6.
 - b. Casings with Galvanized-Steel Outer and Inner Skins: Galvanized steel.
 - c. Casings with Galvanized-Steel Outer Skin and Aluminum or Stainless Steel Inner Skins: Stainless steel.

- d. Casings with Stainless Steel Outer and Inner Skins: Stainless steel.
- 3. Seals: Seal interior and exterior joints and seams to make casing air- and watertight. Trim factory-applied sealant flush with adjacent surface.
- 4. Double-Wall Casings: Consisting of insulation sandwiched between an outer and inner metal wall.
- 5. Penetrations: Seal voids around conduit, piping, and tubing penetrations.
 - a. Walls and Roofs:
 - 1) Conduit, Pipe, and Tube Sizes NPS 3 (DN 80) and Smaller:
 - a) Seal void through casing with a nonhardening vapor-barrier caulk covered by an escutcheon on both interior and exterior sides of casing. Back caulk using formed insulation within a sheet metal sleeve.
 - b) Seal void using a friction fit neoprene or EPDM sheet material attached to casing using a bed of adhesive.
 - c) Cover penetration and sealing sheet material with metal escutcheon matching adjacent casing material.
 - 2) Larger Conduit, Pipe, and Tube Sizes: Seal annular void using an adjustable compression-type sealing sleeve.
 - b. Floors: Route conduit, pipe, and tube within a floor-mounted pipe sleeve.
 - 1) Sleeve:
 - a) Fabricate sleeve of aluminum, galvanized-steel, or stainless steel pipe.
 - b) Extend top of sleeve above adjacent floor surface to prevent standing water on floor from entering annular space of sleeve.
 - c) Seal sleeve to top of floor for an air- and watertight seal.
 - 2) Seal annular void of sleeve using an adjustable compression seal.
- 6. Floor Openings with Metal Grating:
 - a. Factory install walk-on safety gratings over any floor opening large enough to create a safety hazard for operators including, but not be limited to, supply-, return-, and exhaust-air openings.
 - b. Mounting Frame:
 - 1) Mount grating in a continuous structural angle or bar frame so no ends of grating bars are exposed. Top of frame to be flush with top of grating.
 - 2) Secure grating to frame with threaded hardware so grating does not move when walked on but can be easily removed from top to gain access behind grating.
 - 3) Continuously weld mounting frame to air-handling unit floor.
- 7. Duct Connections - Direct to Casing: Frame and reinforce unit casing around perimeter of unit duct openings to accommodate direct attachment of field-installed ductwork. Coordinate requirements with Installer to accommodate field connection.

B. Materials for Outer Skin of Casing Walls and Roofs:

1. Galvanized-Steel Solid Sheet: ASTM A653/A653M; G90coating; minimum (nominal) 18 gauge thick.
2. Unit exterior shall be primed and finished with rust inhibiting epoxy paint. Color shall be industrial Grey

C. Materials for Inner Skin of Casing Walls and Roofs:

1. Galvanized-Steel Solid Sheet: ASTM A653/A653M; G90 coating, minimum (nominal) 16 gauge thick.
2. Galvanized-Steel Perforated Sheet: ASTM A653/A653M; G90 coating, minimum (nominal) [16 gauge thick.

D. Materials for Floor Walking Surface:

1. Galvanized-Steel Solid Sheet: ASTM A653/A653M; G90 coating; minimum (nominal) 16 gauge thick.

E. Materials for Underside of Floor Insulation:

1. Galvanized-Steel Solid Sheet: ASTM A653/A653M; G90 coating, minimum (nominal) 20gauge thick.
2. Application: See Drawings for application of different materials indicated.

F. Surfaces in Contact with Airstream:

1. Comply with ASHRAE 62.1 and NFPA 90A.

G. Insulation for Casing Walls, Floors, and Roofs:

1. Materials Not Exposed to Airstream: Closed cell foam insulation with a heat transfer factor not great than 0.06 Btu/hr/sq ft/°F.
2. Thickness: Minimum 2 inches
3. Insulation shall completely fill the casing cavity so no voids exist.

H. Access Doors:

1. Application: Install access doors in air-handling units at locations indicated on Drawings and to provide access to all components requiring maintenance.
2. Adjustment: Design doors for field adjustment capable of maintaining specified leakage rate.
3. Mounting Height: Install bottom of door frame within 2 inches of air-handling unit floor walking surface.
4. Performance: Leakage as required to satisfy overall unit leakage performance indicated, but not more than 1.0 cfm] per door when tested at 10 inches wg.
5. Fabrication: Formed and reinforced, constructed of same materials and thicknesses as casing. Where doors are installed in casing walls with perforated interior, install doors with solid interior.
6. Swing: Arrange doors to be opened against pressure, unless otherwise indicated on Drawings.
7. Frame: Galvanized steel with welded mitered corners.
8. Handles:

- a. Secure door closed using not less than two roller-style latches with handles located at quarter points along door height.
 - b. If three latches with handles are included, install one at midpoint of door height and equally space others.
 - c. Air-handling unit manufacturer has option to use a multipoint latching mechanism that is operable from a single door handle located at midpoint of door height, but secures door to frame at top, bottom, and handle location.
 - d. Include door handles on outside and inside of door to allow operator access to open and close door from outside and inside of unit.
 - e. Field adjustable to accommodate changes to fit and gasket compression.
 - f. Durable product capable of withstanding repeated opening and closing of door while operating under design pressure without damage.
9. Hinges: Full-length, concealed, stainless steel piano hinge.
10. Gasket:
- a. Design: Specially formed with an internal air chamber specifically designed to seal on two surfaces without taking a permanent set.
 - b. Dual Gaskets: Primary and secondary gasket.
 - c. Location: Install gaskets around entire perimeter of doors or frames.
 - d. Material: EPDM, neoprene, or santoprene.
 - e. Protection: Seat gasket in a protective metal ribbed chamber integral to door or door frame to protect gasket from damage by operator incidental contact.
 - f. Service: Field replaceable.
 - g. Adhesive-backed tape-type gaskets adhered to a single flat surface are unacceptable.
11. Size of Door Frame Clear Opening: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components.
- a. Width: At least 24 inches clear inside of door frame.
 - b. Height: Full clear height of unit casing up to a maximum height of 72 inches clear inside of door frame.
 - c. Door sizes indicated on Drawings.
12. Safety Latches and Stops:
- a. Safety Latches: Install safety latch with retainers on outward swing doors that do not open against pressure to allow restricted travel for purpose of pressure relief and so that doors do not open uncontrollably due to inside pressure.
 - b. Stops: Install cushioned door stops on inward swinging doors where necessary to limit door travel that could potentially damage the door or internal components.
13. Tie-Backs: Install tie-backs with retainers on outward-swinging access doors to hold doors in an open position during service.
14. Locks: Include each access door with an integral key lock. Pad locks are unacceptable.
- a. Incorporate key lock into door handle where feature is available.
 - b. A common key shall be used to lock and unlock access doors of all air-handling unit(s).
 - c. Include two keys for each air-handling unit.
 - d. Lock access doors at factory to ensure that unauthorized access is in place before air-handling unit packaging and shipment.

15. Test Ports.
 - a. Provide all access doors with test ports.
16. Nameplates:
 - a. On each access door, include a nameplate defining the access to service within. Nameplates shall be included for, but not be limited to, the following:
 - 1) Dampers.
 - 2) Filters.
 - 3) Cooling Coils.
 - 4) Electric Heaters.
 - 5) Heat Wheels.
 - 6) Fixed Plate Exchangers.
 - 7) Supply Fans.
 - 8) Exhaust Fans.
 - 9) Air-handling unit designation.
 - 10) Where door access is to multiple components, list all components accessed. For example: Filter/Cooling Coil.
 - 11) For each door that does not open against static pressure, include a warning sign stating: "DANGER: DOOR UNDER PRESSURE. DO NOT OPEN WITH FAN ON."
 - b. Lettering Size and Style: At least 1-inch-high, block style.
 - c. Material: Lettering engraved in black plastic on a white plastic back. Engraving shall penetrate through black plastic so lettering reads white.
 - d. Attachment: Attach nameplates to door using high-strength bonding cement and [stainless steel]screws.
 - e. Mounting Location:
 - 1) For access doors without windows, locate top of nameplate 6 inches from top of door and center in door width.
 - 2) Align nameplates of all doors for uniform placement.
- I. Standing-Seam Metal Roof: Construct air-handling unit roof casing with standing seams designed for waterproof roofing applications.
 1. Construct air-handling unit roof using same materials and finish as walls.
 2. Slope roof away from primary access side of unit at not less than 2 percent
 3. For air-handling units shipped in multiple sections, include standing-seam joiners at each split with adhesive, hardware, and cover strips for field joining by Installer.
- J. Piping Enclosures:
 1. Description: Integral accessible enclosure(s) to house field-installed piping from below.
 2. Size: Adequate clearance for field installation of piping, valves, accessories, and associated insulation.
 - a. Maintain at least 6 inches of clearance between inside of enclosure and face of pipe insulation at most restricted point.
 3. Construction:
 - a. Base, Walls, and Roof: Match air-handling unit.
 - b. Floor: Not required, open to below.

c. Access Doors:

- 1) Size for full front access to piping, valves, and accessories installed within enclosure.
- 2) Double-door applications with removable center mullions for unrestricted access.

4. Electrical: Factory install and wire service light with switch and receptacle for each enclosure.

2.8 **WALL LOUVERS**

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A. Wall Louvers, Drainable Blade:

1. Source Limitations: Obtain louvers from single source from single manufacturer.
2. Performance:
 - a. Air Pressure Drop, Design: Less than [0.1 inch wg] <Insert pressure drop> at airflow indicated on Drawings.
 - b. Air Pressure Drop, Rating: Less than 0.1 inch wg at free area intake face velocity of 700 fpm.
 - c. Face Velocity: If louver size is not indicated on Drawings, size louver for 500-fpm velocity across louver free area.
 - d. Free Area: 54 percent or more for a 48-by-48-inch representative sample.
 - e. AMCA 500-L: Beginning point of water penetration at 870 fpm.
3. Features:
 - a. Depth: 4 inches.
 - b. Frame: 0.080 inch thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy.
 - c. Blades: 0.080 inch thick, ASTM B211, Grade 6063, T5 temper, extruded-aluminum alloy; stationary in horizontal position, drainable.
 - d. Stationary vertically positioned blades.
 - e. Bird Screen: 0.5-by-0.040-inch expanded flattened aluminum attached to back of louver.
 - f. Finish: Match exterior casing.
4. Air-Handling Unit Factory Assembly:
 - a. Install louver face flush with exterior of casing and seal to provide a weathertight installation.
 - b. Secure louver in casing and include additional bracing if required to handle loading of extreme outdoor environmental performance indicated.
 - c. Provide weather hood over each louver.
5. Application: Factory install louvers in air-handling casing for each outdoor intake and exhaust discharge.

2.9 **INTERNAL STRUCTURAL SUPPORTS**

A. General:

1. Air-handling unit manufacturer shall design and assemble air-handling unit internal structural supports for attachment and support by air-handling unit structural base.

2. Factory install structural supports for internal support casing if required to comply with casing structural performance.
3. Factory install hoist beams and rails over equipment to comply with performance requirements for service.

B. Structural Member Size and Spacing:

1. Size: Air-handling unit manufacturer shall select size of members and construction to do the following:
 - a. Withstand the rigors of loading, unloading, shipping and rigging without damage to air-handling unit components or misalignment of factory-assembled casing and components.
 - b. Comply with performance requirements indicated.
2. Spacing: Positioned as required to comply with requirements.

C. Materials: Structural carbon steel, ASTM A36/A36M.

1. Structural Supports: Angle, channel, I or W beam shapes, or tube shapes selected by air-handling unit manufacturer for application.
2. Hoist Beams for Internal Components (Spanning Full Width of Unit): I or W beam shapes.

D. Carbon-Steel Finish: Carbon-steel bases shall be shot-blasted, cleaned, prepared, and painted or hot-dip galvanized after fabrication.

2.10 FACTORY-MANUFACTURED ROOF CURBS

A. General:

1. Air-handling unit manufacturer shall furnish a continuous perimeter curb for each air-handling unit.
2. Design curb to support operating air-handling unit from its base with attachments to withstand environmental forces. Curbs with intermediate reinforcing as required.
3. Frame curb for ductwork, piping, and conduit located within curb.
4. Fabricate curb to maintain top of curb level even where installed on sloping substrate.
5. Furnish top of curb to provide for field attachment of unit base to curb.
6. Furnish curb with a fully mitered and raised cant where required by adjacent insulation and roofing.
7. Include bottom of curb with attachment flange that extends beyond base of curb and is suitable for attachment to substrate.
8. Furnish curb with integral crickets if required by roof installation.
9. Furnish curb with 2" integral spring isolators.

B. Size:

1. Size curb to provide continuous support of unit base and to fit within footprint of unit perimeter base.
2. Height:
 - a. 18 inches from top of curb to finished roofing surface at highest point along perimeter of curb.

C. Materials:

1. Galvanized-Steel Solid Sheet: ASTM A653/A653M; G90 coating; minimum (nominal) 12gauge thick. Treat welded areas to protect against corrosion with a zinc-rich coating.

D. Insulation:

1. Insulate curb to provide thermal performance equal to unit casing.
2. Completely encapsulate insulation within metal curb.

E. Gaskets:

1. Include a continuous gasket between air-handling unit base and top of curb for an air and watertight seal.
2. Select gasket materials suitable for installation while complying with requirements indicated.
3. Furnish gasket materials with air-handling units and curbs for field installation.
4. Air-handling unit manufacturer to provide instruction to installer on proper installation techniques.

2.11 CENTRIFUGAL PLENUM FANS

A. Source Limitations: Obtain fans from single source from single manufacturer.

B. Operating Performance:

1. Air-handling unit manufacturer shall account for, and include in, submitted fan selections any static pressure drops associated with unit, and system effect due to fan operating in the air-handling unit.
 - a. Add additional static pressure to fan scheduled total static pressure.
 - b. If fan motor horsepower is increased, notify Architect.
2. Fans shall have sharply rising pressure characteristics at operating point and stable in operation. Fan horsepower characteristics shall be self-limiting and non-loading.
3. Fan speed, brake horsepower, and sound power levels indicated are maximum acceptable.
4. Motor horsepower, airflow rate, and static pressure are minimum acceptable. Motor horsepower shall be capable of handling maximum horsepower of fan at scheduled speed.
5. Fan air performance ratings shall be based on tests in accordance with ASHRAE 51/AMCA 51 and AMCA 210.
6. Base fans sound ratings on AMCA 300 and calculation methods in accordance with AMCA 301.
7. At a minimum, fans shall have AMCA class indicated on Drawings.
 - a. Fan operating limits shall be in accordance with AMCA 99 for AMCA class indicated.
 - b. If AMCA class is not indicated, use AMCA 99 as basis for determining AMCA class.
 - c. AMCA class selected shall be capable of accommodating a plus 10 percent increase to fan static pressure indicated on Drawings.
8. Motor starting torque shall exceed fans speed-torque requirements.

C. Vibration Balance:

1. Each fan/motor assembly shall be factory balanced to AMCA 204, BV-3, Balance Quality Grade G6.3 or better through entire operating speed range from minimum speed to maximum speed. If minimum speed is not indicated on Drawings, assume minimum speed to be 20 percent of design speed.
 2. Identify and record each speed and speed range within the fan operating range that could cause potential vibration problems.
 3. Submit test reports as an information submittal for Project record.
- D. Operation and Service Requirements:
1. Each fan/motor assembly shall be capable of lock-out/tag-out procedure without interrupting operation of other fans in air-handling unit.
 2. Design and incorporate features to permit safe, rapid, and economical maintenance.
- E. Fan Base:
1. Mount fan, motor, and drive on a structural-steel or an aluminum base.
 2. Electrically weld the base.
 3. Size and design the base construction to withstand the rigors of shipping and rigging.
 4. Include the base with lifting lugs or holes.
- F. Fan Panel:
1. Construct fan panel of aluminum or powder-coated steel.
 2. Support fan wheel and bearings from a structural aluminum or powder-coated steel framework.
 3. Reinforce and brace fan panel to prevent vibration and pulsation.
 4. Include stiffeners to form a rigid panel that is free of structural resonance and vibration.
- G. Fan Inlet and Wheel Cone:
1. Precision-spun or die-formed, matched inlet and wheel cone to ensure streamlined airflow into the wheel and full loading of blades.
 2. Inlet and wheel cones shall be hyperbolic.
 3. Inlet cone shall be a single piece, constructed of aluminum or powder-coated carbon steel.
 4. Fasten inlet cone to fan panel using bolts, nuts and washers to provide a positive and secure attachment that can be field removable.
 5. Inlet cones that are held in place using retaining clips are unacceptable.
- H. Fan Wheel:
1. Fan blades shall be a true hollow airfoil shape, continuously welded to backplate and wheel cone.
 2. Construct blades of aluminum, reinforced for AMCA fan class and operating conditions scheduled.
 3. Design blades to provide smooth and aerodynamic airflow over all surfaces of blade.
 4. Construct fan hubs of cast aluminum or cast-iron ASTM A48/A48M Class 20A and better, with integral bracing for extra strength and stiffness.
 - a. Castings shall be sound and free of shrink holes, blow holes, cracks, scale, blisters, or other similar injurious defects.
 - b. Clean surfaces of castings by blasting, pickling, or other standard method.

- c. Mold-parting fins and remains of gates and risers shall be chipped, filed, and ground flush.
 - d. Design hubs to maintain a high resistance to fatigue and low relative wheel imbalance.
 - 5. Hubs shall be keyed and setscrewed to shaft for positive attachment.
 - 6. Construct the wheel backplates of aluminum.
 - 7. Statically and dynamically balance fan wheel before fan is assembled.
 - 8. Select entire rotating assembly so first critical speed is at least 30 percent greater than fan design speed and at least 20 percent greater than maximum AMCA class speed.
- I. Fan Drive:
- 1. Direct drive, arrangement 4 in accordance with AMCA 99 for single-width, single-inlet fans.
 - 2. Adjust wheel width and diameter to match motor speed while providing performance scheduled.
 - 3. Fasten fan wheel directly to motor shaft using a key and setscrew as previously specified.
 - 4. Construct motor base and pedestal of aluminum or powder-coated carbon-steel plate.
 - 5. Fan Speed Limitation: Fan speed at design conditions indicated shall not exceed speed on motor nameplate for direct-drive applications. Do not select fans to operate at motor speeds greater than motor nameplate.
- J. Protective Screens: Factory furnish and install protective screens on fan inlet and discharge.
- 1. Expanded metal or welded wire welded to a painted carbon-steel or stainless steel frame.
 - 2. Screens shall comply with OSHA requirements.
 - 3. Screens shall be constructed of painted carbon or stainless steel.
 - 4. Fasten screens to fan frame for easy removal by maintenance personnel.
- K. Welding:
- 1. Use AWS- or ASME-certified welders to weld materials required by application.
- L. Hardware: Hex-head, high-strength carbon steel or 300 series stainless steel.
- M. Airflow Measurement:
- 1. Provide each fan with piezo rings for airflow measurement by ATC Sub-subcontractor.
 - 2. Flow monitoring station shall monitor the pressure difference between the fan inlet and the smallest diameter of the inlet cone.
 - 3. Volumetric flow to be calculated from empirically derived formulas based on testing by the fan manufacturer.
 - 4. Flow monitoring station shall not use air restricting flow devices that reduce fan performance or create additional fan sound.
 - 5. Two (2) equidistantly spaced sensor orifices to be drilled in the smallest diameter of the inlet cone venturi. Pressure tubes from each venturi port shall be joined and single averaging tube to the exterior of the fan housing.
 - 6. High-pressure flow port(s) shall be mounted in low velocity fan inlet. Flow ports from the high-pressure sensor shall extend to the exterior of the fan housing.
 - 7. Termination locations shall include a low-pressure connection, a high-pressure connection and a listing of the empirically determined flow rate coefficient.
- N. Nameplates:

1. Construct nameplates and rotation arrows of aluminum or 300 series stainless steel.
2. Securely fasten nameplate and rotation arrow to fan housing using pins or sheet metal screws.
3. Locate nameplates in a highly visible location on motor side of fan.
4. Provide the following information on nameplate: Engraved, stamped, or labeled.
 - a. Manufacturer, address, phone number, and website address.
 - b. Manufacturer model number.
 - c. Serial number.
 - d. Manufacturing date.
 - e. Fan size.
 - f. Design airflow.
 - g. Design static pressure.

O. Air-Handling Unit Factory Assembly:

1. Internal Access: Include each fan with internal access as indicated on Drawings.
2. Removal and Replacement: Each fan shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
3. Fan Supports:
 - a. Construct a freestanding and self-supporting structural framework to support each fan individually from and independent of adjacent fans.
 - b. Construct frame work from aluminum, galvanized steel, painted steel, or stainless steel.

2.12 FAN MOTORS

- A. Source Limitations: Obtain motors from single source from single manufacturer.
- B. Standard: Comply with NEMA MG 1 unless more stringent requirements are indicated.
- C. Description: NEMA MG 1, Design B, as required to comply with capacity and torque characteristics; medium-induction motor.
 1. Performance:
 - a. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
 - b. Efficiency: NEMA Premium Efficiency rating complying with NEMA MG 1.
 - c. Motor Horsepower: Minimum size as indicated on Drawings. Motor shall operate fan under all conditions indicated without exceeding motor nameplate and without use of motor service factor.
 - d. Inverter-Duty Rating: Comply with minimum requirements of Class F or Class H insulation, suitable for "inverter-duty" or "drive-duty" applications in accordance with NEMA MG 1. Motor operation through a variable-frequency controller shall not adversely affect the motor performance, operation, useful life, and warranty.
 - e. Service Factor: 1.15.
 - f. Temperature Rise: Match insulation rating.
- D. Enclosure Type: TEFC.

E. Shaft Grounding System:

1. Shaft grounding system to protect bearings from induced voltage.
2. Shaft grounding system shall have low drag (less than 0.05 percent of motor horsepower), and shall operate for a minimum of three years without periodic maintenance or adjustments.
3. Mounting: External to motor enclosure.

F. Frame:

1. Frames with integrally cast feet unless other requirements of driven equipment require a different arrangement.
2. Frame, front and back end brackets, and front and back end bearing intercaps constructed of cast iron, ASTM A48/A48M, Class 25 or better.

G. Rotor:

1. Fabricate rotor frame from die-cast aluminum, copper, or associated alloys.
2. Key rotors to motor shaft.
3. Rotating assembly shall be dynamically balanced to within limits defined in NEMA MG 1.
4. Motors shall have the entire rotating assembly between bearing inner caps coated with a corrosion-resistant coating.

H. Stator:

1. Copper windings shall be spike resistant to withstand 1600 peak V.
2. Entire wound and insulated stator coated with a coating to protect against moisture and corrosion.

I. Shaft:

1. Solid shaft fabricated of carbon steel, accurately turned, ground and polished, and inspected for accuracy.
2. End of shaft with drilled hole for use in field measurements.

J. Bearings:

1. Grease-lubricated ball or roller bearings.
2. ABMA 11 L-10 motor bearing life of 100,000 hours.
3. Bearing Lubrication:
 - a. Factory lubricate motor bearings using a premium moisture-resistant polyurea thickened grease with rust inhibitors suitable for extreme operating temperatures encountered.
 - b. Coordinate special requirements that may impact lubrication and include appropriate lubrication.
4. Grease Fittings:
 - a. Equip each bearing housing with an easily accessible grease inlet.
 - b. Fit grease inlets with a grease fitting and protective fitting cap.
 - c. Equip inlets with an automatic grease relief fitting to prevent excessive greasing.
 - d. Equip each bearing housing with grease drain and threaded plug.

K. Conduit Box:

1. Material same as frame.
2. For motor frames 365T and below, furnish conduit boxes sized with internal volumes in accordance with NEMA MG 1.
3. For motor frames larger than 365T, furnish conduit boxes one size larger than NEMA MG 1.
4. Coordinate the location and mounting of conduit box with driven equipment manufacturer.
5. Factory mount conduit box on motor.

L. Grounding: NRTL-listed clamp-type grounding lug mounted in conduit box.

M. Motor Leads:

1. Non-wicking type, Class F temperature rating or better and permanently numbered over entire length for identification.
2. Lead terminals shall be manufacturer's standard.

N. Condensate Drains:

1. Motor with drain holes at the lowest point for drainage of condensate.
2. Each drain hole with a threaded removable plug.

O. TEFC Motor Fans: Corrosion-resistant construction, non-sparking, metallic or non-metallic, bi-directional, and keyed to shaft.

1. Motor Fan Cover: Same material as frame.

P. Hardware: Hex-head, high-strength, zinc-plated carbon steel or stainless steel.

Q. Lifting Eyebolts: Eyebolt threaded into frame receptacle and design to prevent moisture and other foreign material from entering motor cavity when eyebolt is removed.

R. Nameplates:

1. Construct nameplates of aluminum or stainless steel and attach to motor frame with aluminum, stainless steel, or brass drive pins.
2. Engrave or stamp data on the nameplate.
3. At a minimum, include nameplate data in accordance with NEMA MG 1.

S. Paint: Successfully pass 1000-hour salt spray test for corrosion in accordance with ASTM B117.

2.13 REFRIGERANT COILS

A. Source Limitations: Obtain coils from single source from single manufacturer.

B. General: Provide air-handling units with refrigerant coils where indicated on Drawings.

C. Description: Plate fin coils constructed of staggered tubes mechanically expanded into continuous collars that are die formed into plate fins. Coils shall be counterflow circuited and equipped with pressure-type distributors. Distributor tubes shall be of equal length to ensure equal distribution of refrigerant to each circuit.

D. Circuited: Interlaced.

E. Performance:

1. Capacities, face area, and number of rows indicated on Drawings are minimum acceptable.
2. Air pressure drop, fin spacing, and face velocity indicated on Drawings are the maximum acceptable.
3. Rate coils in accordance with AHRI 410 when tested in accordance with ASHRAE 33.
4. Coil performance variables and selection procedures shall be in accordance with AHRI 410.
5. Coils piping connections on same end of coil.
6. Coils shall be rated for system operating flows, pressures, and temperatures encountered by installation.
7. Coil selection criteria, unless otherwise indicated on Drawings, are as follows:
 - a. Face Velocity: Maximum of 500 fpm
 - b. Fin Height: Maximum of 48 inches
 - c. Fin Spacing: Maximum of 12 fins per inch.
8. Cooling coils shall have no moisture carryover at design conditions. Install moisture eliminators on discharge face of coil if it is necessary to eliminate moisture carryover.

F. Casing and Tube Sheets:

1. Depth: Extend coil casing and tube sheets a minimum of 1/2 inch beyond face of fins on both entering and leaving side.
2. Casing and Tube Sheet Materials: Stainless steel, ASTM A240/A240M or ASTM A480/A480M, Type 316L, No. 2D finish.
3. Top and Bottom Casings:
 - a. Flange face minimum of 1-1/2 inches; double flange edge for rigidity and ease of removal with secondary flange face minimum of 1/2 inch.
 - b. Thickness: Minimum of 16 gauge thick.
4. End Tube Sheets:
 - a. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - b. Flange face minimum of 1-1/2 inches.
 - c. Thickness: Minimum of 16 gauge thick.
5. Intermediate Tube Sheets:
 - a. Tube sheet holes rolled to prevent chaffing of tubes during thermal expansion and contraction.
 - b. Space intermediate tube sheets a maximum of 48 inches o.c. and locate to provide equal spacing between tube sheet across coil tube length.
 - c. Flange face minimum of 1/2 inch.
 - d. Thickness: Minimum of 16 gauge thick.
6. Holes: Include number, size, and location of holes in casing and end tube sheets required for coil installation.

G. Fins:

1. Collars: Full collars for accurate fin spacing and maximum tube contact while leaving no surface of tube exposed.
 2. Configuration: Flat face or enhanced ripple fins as required by performance.
 3. Materials:
 - a. Aluminum or Copper: 0.0075 inch thick.
- H. Headers:
1. Construct header of seamless copper, ASTM B75/B75M drawn temper of diameter and wall thickness based on coil size, flow rate, design pressure, design temperature, and circuiting.
 2. Tube-to Header Connections: Tube-to-header holes shall intrude inward so landed surface area is three times the core tube thickness to provide enhanced header to tube joint integrity. Tubes shall evenly extend within the ID of the header no more than 0.12 inch.
 3. Header Top and Bottom Caps: End caps shall be die-formed and installed on the ID of header such that the landed surface area is three times the header wall thickness.
 4. Protect openings to prevent entry of dirt into the coil.
- I. Tubes:
1. Material: Copper, ASTM B75/B75M annealed temper or ASTM B280 drawn temper.
 2. Tube Nominal Diameter: Selected for performance indicated.
 3. Tube Nominal Wall Thickness: As required by performance, minimum of 0.035 inch thick.
- J. Tube Return Bends: 180-degree bends brazed to tubes; material, wall thickness, and nominal diameter to match tubes.
- K. Brazing: High-temperature brazing alloy with not less than 5 percent silver.
- L. Hardware: Use hex-head bolts, nuts, and washers constructed of Type 316 stainless steel.
- M. Nameplates: Aluminum or stainless steel nameplate with brass or stainless steel chain for each coil, with the following data engraved or embossed:
1. Manufacturer name, address, telephone number, and website address.
 2. Manufacturer model number.
 3. Serial number.
 4. Manufacturing date.
- N. Cleaning: Residual manufacturing oils and solid contaminants shall be removed internally and externally by completely submersing the coil in an environmentally acceptable degreasing solution that is chemically compatible with the coil material.
- O. Air-Handling Unit Factory Assembly:
1. Coil Connections: Cap coil connection. VRF condensing units shall be connected by installing contractor in the field.
 2. Internal Access: Provide each coil with internal access as indicated on Drawings.
 3. Removal and Replacement: Each coil shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
 4. Supports for Coils:

- a. Construct a freestanding and self-supporting structural framework to support each coil individually from and independent of adjacent coils.
- b. Construct framework for cooling from aluminum or stainless steel structural shapes.

2.14 DRAIN PANS

A. General:

1. Include a drain pan for each cooling coil.
2. Continuously weld drain pan seams, joints, and mitered corners to make the assembled drain pan watertight.
3. Drain pans shall be located under the entire coil and provide full coil coverage including coil return bends and headers.
4. Slope drain pans in multiple directions toward low point drain connection at a uniform slope of at least 2 percent from high point to low point.
5. Include stainless steel blank-offs to prevent air from bypassing around coil.

B. Intermediate Drain Pans:

1. Where multiple individual horizontally mounted coils are vertically stacked to make a coil bank, install intermediate drain pans under each stacked coil in the coil bank.
2. Material: Type 316L stainless steel ASTM A240/A240M or ASTM A480/A480M, a minimum of 16 gauge thick.
3. Extend drain pan beyond air entering face of coil casing at least 3 inches.
4. Extend drain pan beyond air leaving face of coil casing at least 6 inches.
5. Drain Pan Connection:
 - a. Stainless steel threaded coupling welded to underside of drain pan at lowest point.
 - b. Minimum Nominal Connection Size: NPS 1.5.
6. Drain Pipe:
 - a. Air-handling unit manufacturer to connect full-size drain pipe to each drain pan connection. Option to use one of following pipe materials:
 - 1) Copper tube with a bronze threaded male adapter, brazed or solder to end.
 - b. Extend drain pipe to top of drain pan immediately below.
 - c. Include a removable stainless steel support to secure bottom of drain pipe from drain pan below to prevent lateral movement.
 - d. In applications where multiple drain pans are stacked, align stacked drains pan connections and pipes for clear vertical flow.

C. Bottom Drain Pans:

1. Mounting Location, Recessed in Floor: Air-handling unit manufacturer shall recess bottom drain pan into the floor.
2. Grating: Install removable stainless steel grating on top of drain pan.
3. Material: Type 316L stainless steel ASTM A240/A240M or ASTM A480/A480M, a minimum of 16 gauge > thick.
4. Minimum Depth: 1.5 inches <Insert depth>.
5. Extend drain pan beyond air entering face of coil casing at least 3 inches.
6. Extend drain pan beyond air leaving face of coil casing at least 12 inches.

7. Drain Pan Connection:
 - a. Stainless steel threaded half-coupling welded to lowest point of drain pan.
 - b. Location: One end.
 - c. Minimum Nominal Connection Size: NPS 1.5.
8. Drain Pipe:
 - a. Air-handling unit manufacturer to connect full size drain pipe to each drain pan connection. Option to use one of following pipe materials:
 - 1) Copper tube with threaded male adapter, brazed or soldered to ends.
 - b. Extend drain pipe and terminate 3 inches beyond exterior face of casing.

2.15 ELECTRIC HEATERS

- A. Source Limitations: Obtain heaters from single source from single manufacturer.
- B. General:
 1. Provide air-handling units with electric heaters where indicated on Drawings.
 2. NRTL listed for zero clearance to combustible surface, regardless of heater capacity.
- C. Design and Performance:
 1. Heaters and installation shall comply with NFPA 70.
 2. Scheduled capacity (kW) is minimum acceptable.
 3. Air pressure drop and face velocity are maximum acceptable.
 4. Rate heaters output capacity at voltage, phase, and hertz indicated on Drawings.
 5. Arrange capacity control to minimize stratification.
 6. Equally balance heater electrical load for each step across all three phases.
 7. Part-Load Operation: Include multiple heaters configured in a parallel arrangement with operation staged if required for uninterrupted heater operation over the full range of air-handling unit airflow down to the minimum airflow indicated (minimum airflow shall be 25% of design airflow).
 - a. Where multiple heaters positioned in a parallel arrangement are required for operation over the full range of air-handling unit airflow, include an automatic isolation damper at the discharge of inactive heaters to isolate airflow across inactive heaters while other heaters are operating.
- D. Heating Elements:
 1. Finned Tubular Elements:
 - a. Coiled resistance wire of 80 percent nickel and 20 percent chromium; center-mounted and surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
 - b. Finish finned tubular elements with a baked-on aluminum paint, and mount in a frame.
 - c. Each element individually removable from terminal box.
 - d. Use threaded stainless steel element terminals and hardware.

- E. Frame: Galvanized steel; include intermediate element support brackets equally spaced at a maximum of 36 inches o.c. across heater element length.
- F. Terminal Box/Control Panel: Unit mounted; with disconnection means and overcurrent protection.
 - 1. Enclosure: NEMA 250, Type 1 or Type 12 enclosure complying with UL 50.
 - 2. Full face hinged door with lock and key latching device(s).
 - 3. Factory insulate base of terminal box to prevent condensation from occurring within box.
 - 4. Mount terminal box control panel on exterior surface of air-handling unit casing. Gasket and seal air-handling unit cabinet penetrations.
 - 5. Install a laminated elementary wiring diagram on inside face of heater control panel door or in another protected location than visible be service personnel. Wiring diagram shall match installation.
- G. Controls:
 - 1. Safety Controls: Each heater with following factory-mounted safety controls:
 - a. Disk-type thermal cutout switch with automatic reset.
 - b. Primary linear thermal limit cutout switch with automatic reset.
 - c. Secondary linear thermal limit cutout switch with local manual reset.
 - d. Airflow Proving Switch: Diaphragm-operated pressure differential type; with pressure range selected to ensure reliable operation throughout full range of air-handling unit airflow down to minimum airflow indicated.
 - 2. Staging Control: Magnetic contactors for switching stages of heat except for air-handling units located in occupied spaces, include mercury contactors for switching stages of heat.
 - 3. SCR Control: Silicon-controlled rectifier (SCR) for 100 percent stepless capacity control.
 - 4. Remote Monitoring and Control: Include control devices necessary to interface with remote-control signals including the following:
 - a. Heater on/off control.
 - b. Monitoring heater on/off status.
 - c. High-temperature alarm.
 - d. Low-airflow alarm.
 - e. Heater capacity control.
- H. Electrical:
 - 1. Single-Point Field Power Connection: Install and wire the heater to accommodate a single field electrical connection for electrical power.
 - 2. Disconnecting Means: Provide each heater with a main electrical power, door mounted and interlocking, and disconnecting means to prevent access into panel, unless switched in the off position.
 - a. Fused disconnect switch with lockable handle.
 - b. Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than 65,000 A.
 - 3. Factory install and wire branch circuit fusing, or circuit breakers in accordance with NFPA 70.
 - 4. Pilot Lights: Include labeled pilot lights on face of control panel for the following:

- a. Power on.
 - b. Low-airflow alarm.
 - c. High-temperature alarm.
 - d. One for each stage on.
 5. Terminations: Wire terminations and field interface terminations to labeled terminal strips.
 6. Control Transformer: Size control circuit transformer for required load, plus 75 VA.
 7. Labeling: Label each electrical device with a laminated phenolic tag.
 8. Use only NRTL-labeled electrical components.
- I. Nameplate: Include the following data:
1. Manufacturer name, address, telephone number, and website address.
 2. Manufacturer model number.
 3. Serial number.
 4. Manufacturing date.
- J. Air-Handling Unit Factory Assembly:
1. Support individual heater assemblies within unit from a structural framework constructed of galvanized steel.
 2. Provide each heater assembly with access from downstream and upstream sides.
 3. Make provisions in arrangement and installation to mitigate uneven airflow patterns within unit for proper heater operation.
- 2.16 CARTRIDGE FILTERS
- A. Source Limitations: Obtain filters from single source from single manufacturer.
- B. Description: Factory-fabricated, dry, extended-surface, disposable, air filters with media formed in mini-pleats and arranged in a V-shape pattern.
- C. Performance:
1. Minimum Filtration Efficiency, ASHRAE 52.2 MERV Rating: 13.
 2. Energy Cost Index: Five star rating.
 3. Initial Air Pressure Drop: With face velocity of 500 fpm, clean filter pressure drop shall not exceed the following:
 - a. MERV 13 and MERV 13A: 0.25 inch wg.
 4. Manufacturer-Recommended Final Air Pressure Drop: 1.5 inches wg.
 5. Pressure Differential without Failure: 10 inches wg.
 6. Temperature Rating: 175 deg. F.
- D. Certification:
1. AHRI: Tolerances in accordance with AHRI 850 (I-P) and AHRI 851 (SI).
 2. ASHRAE: Tested and rated in accordance with ASHRAE 52.2.
 3. UL: UL 900 listed.
- E. Size:
1. Nominal Filter Size:

- a. Face: 24 by 24 inches.
 - b. Depth: 12 inches.
 - 2. Actual Filter Size: Suitable for installation in an industry-standard filter holding frame.
 - F. Filter Media Surface Area: Each filter shall contain at least 200 sq. ft. for a filter with a nominal 24-by-24-inch face.
 - G. Construction:
 - 1. Media: Microfine glass media formed into mini-pleats and arranged in V-shape patterns.
 - 2. Media Frame: Plastic or corrosion-resistant metal.
 - 3. Adhesive: Fire-retardant bonding adhesive where bonding media to frame.
- 2.17 PLEATED PANEL FILTERS
- A. Source Limitations: Obtain filters from single source from single manufacturer.
 - B. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters.
 - C. Performance:
 - 1. Filtration Efficiency, ASHRAE 52.2 MERV Rating: 8.
 - 2. Energy Cost Index: Five star rating.
 - 3. Initial Air Pressure Drop: With face velocity of 500 fpm, clean filter pressure drop shall not exceed the following:
 - a. MERV 8 :
 - 1) Depth 4 Inches (100 mm): 0.27 inch wg.
 - 4. Manufacturer-Recommended Final Air Pressure Drop: 1.0 inch wg.
 - 5. Pressure Differential without Failure: 2 inches wg.
 - 6. Temperature Rating: 200 deg F.
 - D. Certification:
 - 1. AHRI: Tolerances in accordance with AHRI 850 (I-P) and AHRI 851 (SI).
 - 2. ASHRAE: Tested and rated in accordance with ASHRAE 52.2.
 - 3. UL: UL 900 listed.
 - E. Size:
 - 1. Nominal Filter Size:
 - a. Face: 24 by 24 inches.
 - b. Depth: 4 inches.
 - 2. Actual Filter Size: Suitable for installation in an industry-standard filter holding frame.
 - F. Filter Media Surface Area: Each filter shall contain the following minimum media surface area for a filter with a nominal 24-by-24-inch face:

1. Depth 4 Inches (100 mm); 27.7 sq. ft..

G. Construction:

1. Media: Glass or Cotton and synthetic blend of fibers arranged in a series of pleats attached to and supported by a corrosion-resistant welded-wire grid. Coat media with an antimicrobial agent.
2. Filter Media Casing: High wet strength (28-point) beverage board that is bonded around the periphery to eliminate air bypass.
 - a. Diagonal support members across upstream and downstream filter face constructed of same material as casing shall ensure pleat spacing and stability.
3. Adhesive: Fire-retardant bonding adhesive where bonding media to casing.

2.18 ASHRAE-RATED FILTER HOLDING FRAMES

A. Filter Holding Frames for ASHRAE-Rated Filters:

1. Fabricate filter holding frames with mitered corners and reinforce frame to maintain a durable, rugged, true square shape.
2. Construct frames of galvanized steel. Use stainless steel frames in applications exposed to corrosive airstreams.
3. For applications with pre-filter and final filters sharing the same filter holding frame, frames shall be suitable for supporting and holding both pre-filter and final filters in frame with both filters serviceable from upstream (entering air) side.
4. Frame Depth: At least 2.75 inches.
5. Gaskets: Continuous, suitable for same operating temperature as filters.
6. Filter Clips: Each filter holding frame with spring clip fasteners at each corner. Spring clips shall allow filters to be removed and replaced without use of tools.
7. Frames shall be industry-standard size to provide interchangeability of filters from other manufacturers.

B. Air-Handling Unit Factory Installation:

1. Air-handling unit manufacturer shall furnish filters and provide filter holding frames, retaining clips, and filter support structures.
2. Furnish filter quantity, size, type, and performance indicated on Drawings.
3. Install filter frames in a flat vertical position for horizontal airflow.
4. Install holding frames in accordance with manufacturer's written instructions and to prevent passage of unfiltered air. Include additional gaskets as necessary.
5. Secure individual holding frames together to build a multiple filter bank.
6. Construct galvanized-steel support structure to hold frames and filters.
 - a. Design support structure for maximum system operating pressures encountered equal to fan shutoff pressure.
 - b. Design and fabricate support structure to limit deflection across filter bank to 1/360 of the span when subjected to a 200-lb lateral force applied at any point on the filter holding frame assembly.

2.19 FILTER GAUGES

- A. Provide a gauge to indicate pressure differential between entering and leaving side of each filter bank. Panel filter bank separate from cartridge filter bank.

1. Where multiple filters share a common frame, include a separate gauge for each filter bank.
 2. Include a metal spacer constructed of same material as filter frame for one of the filters installed in filter bank to accommodate pressure differential measure across both upstream and downstream filters.
- B. Gauge shall have a nominal 4-inch-diameter face.
- C. Select range of gauge to be approximately twice the dirty filter pressure drop.
- D. Provide each gauge with vent valves to allow for re-zeroing the gauge without removing tubing connections.
- E. Include static pressure sensors on entering and leaving side of each filter bank.
- F. Air-Handling Unit Factory Assembly:
1. Mount each filter gauge on exterior surface of unit casing near associated filter sections.
 2. Mount center of gauges 60 inches above bottom of air-handling unit structural base.
 3. Connect static pressure sensors to filter gauges using aluminum or stainless steel tubing and compression type fittings.
 4. Support tubing at intervals not greater than 60 inches o.c.

2.20 AUTOMATIC DAMPERS

- A. General: Provide air-handling units with automatic dampers where indicated on Drawings.
1. Unless otherwise indicated, use parallel-blade configuration for two-position control, for equipment isolation service, and when mixing two airstreams. For other applications, use opposed-blade configuration.
 2. Factory assemble multiple damper sections to provide a single damper assembly of size required by application.
- B. Rectangular Dampers with Aluminum Blades:
1. Source Limitations: Obtain dampers from single source from single manufacturer.
 2. Performance:
 - a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.
 - b. Pressure Drop: 0.05 inch wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, figure 5.3.
 - c. Velocity: Up to 4000 fpm.
 - d. Temperature: Minus 40 to plus 185 deg F.
 - e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
 - f. Damper shall have AMCA seal for both air leakage and air performance.
 3. Construction:
 - a. Frame:
 - 1) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.07 inch thick.

- 2) Hat-shaped channel with integral flange(s). Flange mating face shall be a minimum of 1 inch.
 - 3) Width not less than 5 inches.
 - b. Blades:
 - 1) Hollow, airfoil, extruded aluminum.
 - 2) Parallel- or opposed-blade configuration as required by application.
 - 3) Material: ASTM B211, Alloy 6063 T5 aluminum, 0.07 inch thick.
 - 4) Width not to exceed 6 inches.
 - 5) Length as required by close-off pressure, not to exceed 48 inches.
 - c. Seals:
 - 1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
 - 2) Jams: Stainless steel, compression type.
 - d. Axles: 0.5-inch-diameter stainless steel, mechanically attached to blades.
 - e. Bearings:
 - 1) Molded synthetic or stainless steel sleeve mounted in frame.
 - 2) Where blade axles are installed in vertical position, include thrust bearings.
 - f. Linkage:
 - 1) Concealed in frame.
 - 2) Constructed of aluminum and stainless steel.
 - 3) Hardware: Stainless steel.
 4. Airflow Measurement: Include damper assembly with integral airflow monitoring for RTU-1 outside air damper.
 - a. Source Limitations: Obtain damper applications from single source from single manufacturer.
 - b. Zero- to 10-V dc or 4- to 20-mA scaled output signal for remote monitoring of actual airflow.
 - c. Accuracy shall be within 5 percent of actual flow rate between the range of minimum and design airflow. For applications with a large variation in range between the minimum and design airflow, configure damper sections and flow measurement assembly as required to comply with stated accuracy over the entire modulating range.
 - d. Suitable for operation in untreated and unfiltered air.
 - e. Include temperature and altitude compensation and correction to maintain accuracy over temperature range encountered at site altitude.
 - f. Include automatic zeroing feature.
- C. Rectangular Dampers with Insulated Aluminum Blades:
1. Source Limitations: Obtain dampers from single source from single manufacturer.
 2. General: Unless otherwise indicated on Drawings, install insulated aluminum blade dampers in applications where dampers close to outdoors.
 3. Performance:
 - a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure and shall not exceed 4.9 cfm/sq. ft. against 4-inch wg differential static pressure at minus 40 deg F.
 - b. Pressure Drop: 0.1 inch wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, figure 5.3.
 - c. Velocity: Up to 4000 fpm.
 - d. Temperature: Minus 100 to plus 185 deg F.
 - e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

- f. Damper shall have AMCA seal for both air leakage and air performance.
 - 4. Construction:
 - a. Frame:
 - 1) Material: ASTM B211, Alloy 6063 T5 extruded-aluminum profiles, 0.08 inch thick.
 - 2) C-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch.
 - 3) Width not less than 4 inches.
 - 4) Entire frame shall be thermally broken by means of polyurethane resin pockets, complete with thermal cuts.
 - b. Blades:
 - 1) Hollow shaped, extruded aluminum.
 - 2) Blades shall be internally insulated with expanded polyurethane foam and shall be thermally broken. Complete blade shall have an insulating factor of R-2.29 and a temperature index of 55.
 - 3) Parallel- or opposed-blade configuration as required by application.
 - 4) Material: ASTM B211, Alloy 6063 T5 aluminum, 0.08 inch thick.
 - 5) Width not to exceed 6 inches.
 - 6) Length as required by close-off pressure, not to exceed 48 inches.
 - c. Seals: Blade and frame seals shall be of flexible silicone and secured in an integral slot within the aluminum extrusions.
 - d. Axles: 0.44-inch-diameter stainless steel, mechanically attached to blades.
 - e. Bearings:
 - 1) Bearings shall be composed of a celcon inner bearing fixed to axle, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.
 - 2) Where blade axles are installed in vertical position, include thrust bearings.
 - f. Linkage:
 - 1) Concealed in frame.
 - 2) Constructed of aluminum and stainless steel.
 - 3) Hardware: Stainless steel.
 - D. Damper Actuators:
 - 1. Provided by ATC sub-subcontractor. Refer to section 230923 "Direct Digital Control (DDC) System for HVAC" for requirements.
- 2.21 HEAT WHEELS (RTU-1 and 2, HRU-1, 2, 3, & 4, and AHU-8, 9, and 10)
- A. Source Limitations: Obtain heat wheels from single source from single manufacturer.
 - B. Performance:
 - 1. Heat wheels shall be engineered by manufacturer to provide a highly reliable, low-maintenance product for use under continuous operation over an extended operating period of not less than 20 years. Provide supporting documentation if requested to show how features of product design comply with performance indicated.
 - 2. Products with ratings that exceed indicated pressure drop, fall short of sensible and latent recovery performance indicated, or transfer contaminants in excess of requirements indicated are unacceptable and should not be submitted for review and approval.
 - 3. Fully-assembled and -installed heat wheel shall be suitable for use in air systems that supply air to tenant occupied space and shall comply with NFPA 90A and governing building codes.
 - 4. Heat wheel shall be provided with a 10 year parts and labor warranty.
 - C. Testing and Certification:

1. Thermal Performance: Certification by a qualified independent testing organization documenting the following:
 - a. Sensible and latent recovery efficiencies conducted in accordance with ASHRAE 84 with results presented in accordance with ASHRAE 84 and AHRI 1060 (I-P) and AHRI 1061 (SI).
 - b. Sensible, latent, and pressure loss performance over a range of operating points as required by ASHRAE 84 and specifically for actual airflow conditions required by Project.
 2. Cross Contamination: Cross-contamination performance reports to validate compliance with requirements indicated.
 - a. Independent test report shall document desiccant-coated transfer media exhibits 3 or 4 Angstrom behavior and does not transfer pollutants typically encountered in indoor air environment having room operations and functions indicated.
 - b. Testing shall be performed in a test facility complying with ASHRAE 84 for tracer gas testing.
 - c. Challenge gases used for testing shall include chemicals that represent contaminants typically encountered and include at least the following: acetaldehyde, methanol, methyl isobutyl ketone, propane, and xylene.
 3. Flame and Smoke: NRTL test report listing flame-spread index and smoke-developed index of media when tested in accordance with ASTM E84 to comply with requirements indicated.
 4. Microbial Resistance: Test report documenting ability of wheel faces and transfer media to actively limit microbial growth.
 - a. Testing completed by a qualified research institution or testing laboratory using common live bacterial cultures to document antimicrobial performance with 95 percent mortality effectiveness.
 5. Corrosion Resistance: Test report summarizing acid resistance effectiveness of media face coating completed in accordance with ASTM corrosion-test methodologies.
- D. Rotors:
1. Construct rotor media of aluminum base material precoated with a desiccant before forming into honeycomb media structure consisting of circular spiral layers.
 2. Aluminum base material shall be at least 0.0015 inch thick before coating.
 3. Media layers shall be joined together using adhesive to bond between flat and corrugated media layers.
 4. Media Coating:
 - a. Coat media surfaces with a non-migrating solid adsorbent desiccant layer before forming into the structure to ensure that all surfaces are coated.
 - b. Desiccant coating shall be inorganic and use a 3 or 4 Angstrom molecular sieve to achieve desired 3 or 4 Angstrom selectivity, excluding contaminants larger than 3 or 4 Angstroms while effectively transferring water vapor.
 - c. In addition to desiccant coating applied to aluminum substrate, cover two faces of rotor with a two-part polymer coating specifically chosen for chemical resistance and corrosion protection. Coating shall be selected to provide life expectancy indicated when exposed to airstreams encountered.
 - d. Media exposed to airstream shall exhibit effective antimicrobial action to protect against development and spread of microbial contaminants.
 - e. Rotor media with applied coatings and adhesive shall have a flame-spread index less than 25 and a smoke-developed index less than 50 when tested in accordance with ASTM E84.
 5. Media depth shall be determined by heat wheel manufacturer to achieve performance indicated.
 6. Media shall not transfer pollutants typically encountered in an indoor air environment having room operations and functions indicated.
 7. Media shall be cleanable without degrading performance over time.

8. Dry particles up to 800 microns shall pass freely through the media.
 9. Provide segmented rotor media to allow for field installation and replacement of one section at a time without requiring side access. Removal and replacement shall be made while facing rotor media face.
 10. Rotor media shall be held in place by a rigid structural spoke system made of extruded aluminum.
 11. Coat exposed surfaces of aluminum spoke system for corrosion protection.
 12. Rotor structural spoke system shall be designed and manufactured to provide for field installation of media without possibility of media deformation or misfit.
 13. Media shall be secured within structural spoke system by mechanical means, relying on a formed friction fit without use of adhesives or silicone.
 14. Rotors that cannot be installed in air-handling units as a single complete factory assembly coming from heat wheel manufacturer shall be remotely assembled by trained factory service personnel that are employed by heat wheel manufacturer.
- E. Purge Sector:
1. Factory-set, field-adjustable purge sector designed to limit cross contamination to less than 0.04 percent of that of exhaust airstream concentration into supply airstream.
 2. Factory-set, field-adjustable purge sector designed to eliminate cross contamination of exhaust airstream into supply airstream.
- F. Seals:
1. Maintenance-free "non-contact" type to eliminate wear, excessive drag, and resulting added horsepower required for motor drive system, while still being capable of resisting high-pressure differences.
 2. Equip rotor with labyrinth seals, which at no time shall make contact with any rotating surface of rotor face.
 - a. Seals shall be field adjustable and set to within factory-specified tolerances.
 - b. Provide multi-pass seals with four labyrinth stages for optimum performance or alternative design with documented test results showing comparable performance.
 3. Seal shall be secured to housing either by an extruded-aluminum strip with adjustment slots for fastening bolts to the casing frame or by using adjustable clips. Clips shall be made of stainless steel or other noncorrosive material to resist corrosion and possible damage to transfer media.
- G. Shafts:
1. Shaft supporting rotor between bearings shall be one piece, solid steel, accurately turned, ground, polished, and ring gauged for accuracy.
 2. Machine and polish shaft within bearing contact area to comply with bearing manufacturer's written recommended tolerances.
 3. Use a dial indicator to inspect shafts for roundness and straightness.
 4. Coat exposed surfaces of shaft with a corrosion-inhibitive coating.
 5. Shaft shall be machined to provide a shoulder against bearings for a positive locked position to eliminate any lateral movement of rotor due to axial bearing loads.
- H. Bearings:
1. Support rotor shaft by two pillow block bearings designed for an ABMA 11 L-10 life of at least 500,000 hours.
 2. Bearings shall be maintainable and replaceable without removal of rotor from its casing or media from spoke support system.
 3. Grease fittings for each bearing shall be easily accessible and within view of bearing.
 4. Reverse Rotation: Clutch bearing and extended shaft, or equivalent alternative, to prevent reverse rotation and ensure that wheel can only rotate in direction commensurate with effective purge operation.

I. Frame and Housing:

1. Design frame to limit deflection of rotor due to air pressure loss to less than 0.03125 inch, as measured at the outer radius, during maximum rated airflow condition when exposed to a wheel pressure differential of 25 percent above design conditions.
2. Construct rigid frame of welded structural galvanized steel.
3. Designed and manufactured in one, two, or more sections as required by application to provide a rigid structure, when completely assembled, capable of supporting rotor.
 - a. For horizontal airflow applications, support rotor at each end only with no additional support under center.
 - b. For vertical airflow applications, provide one additional bottom center support.
 - c. Clearly mark each section of multiple section units for easy installation.
4. Construct housing of galvanized-steel formed sheets designed to prevent corrosion.
5. Housing shall be reinforced as required to provide a solid mounting surface of peripheral and radial seals, to maintain a fixed distance between rotor surface and any housing part.
6. There shall be no special requirement to provide air-handling unit casing side access for future rotor removal and service. All rotor service shall be performed from inside air-handling unit at face of rotor.

J. Motor and Drive Assembly:

1. Motor Enclosure: Totally enclosed.
2. Motor nameplate horsepower shall exceed maximum load of driven assembly.
3. Multiple belt-drive assembly shall be automatically tensioned and arranged to eliminate any side-to-side movements and slippage.
4. Motor and drive assembly shall be easily accessible and visible for inspection and maintenance.
5. Drive assembly, except motor, shall have a life expectancy of 90,000 hours.

K. Variable-Frequency Controller:

1. Variable-speed control of rotor through a variable-frequency controller.
2. Digital programming with a manual-speed adjustment on the front face of controller.
3. Rotor drive system shall allow for a turndown ratio of 80:1 (20 to 0.25 rpm).
4. Controller with switchable control either locally on front of controller or remotely by a control system.
5. Controller with a motor-rated disconnect switch or circuit breaker having a withstanding rating greater than that required by field electrical power system, but not less than 65,000 A.
6. Controller mounted in a NEMA 250, Type 4 enclosure.

L. Air-Handling Unit Factory Assembly:

1. Internal Access: Provide each heat wheel with internal access from downstream and upstream sides as indicated on Drawings.
2. Removal and Replacement: Each heat wheel shall be independently removable and replaceable through a removable access panel installed in air-handling unit casing.
3. Drain Pans: In applications capable of formation of frost, install condensate drain pans to collect and drain water to exterior of air-handling unit casing.
4. Supports for Heat Wheel:
 - a. Construct a freestanding and self-supporting structural framework to support each heat wheel individually from and independent of adjacent heat wheels.
 - b. Construct frame work from galvanized-steel structural shapes.
5. Comply with heat wheel manufacturer's written installation instructions.

2.22 FIXED PLATE HEAT EXCHANGERS (HRU-5)

A. Fixed Plate Sensible Heat Exchangers:

1. Source Limitations: Obtain heat exchangers from single source from single manufacturer.

2. Description: A device for purpose of transferring only sensible energy from one airstream to another with no moving parts. Design may incorporate parallel, cross- or counterflow construction or a combination of these to achieve the energy transfer.
 3. Performance: Indicated on Drawings with no cross contamination between exhaust and supply airstreams.
 - a. Maximum Pressure Differential: Suitable for maximum 6 inches wg
 - b. Maximum Temperature: Suitable for maximum 194 deg F
 4. Casing: Aluminum
 5. Plates: Evenly spaced, sealed, and arranged for cross airflow.
 - a. Plate Material: Embossed aluminum.
- B. Air-Handling Unit Factory Assembly:
1. Internal Access: Provide each fixed plate heat exchanger with internal access from downstream and upstream sides as indicated on Drawings.
 2. Removal and Replacement: Each fixed plate heat exchanger shall be independently removable and replaceable through a removable access panel or door installed in air-handling unit casing.
 3. Drain Pans: In applications capable of formation of frost, install condensate drain pans to collect and drain water to exterior of air-handling unit casing.
 4. Supports for Fixed Plate Heat Exchanger:
 - a. Construct a freestanding and self-supporting structural framework to support heat exchangers.
 - b. Construct frame work from aluminum, galvanized-steel, or stainless steel structural shapes.
 5. Comply with fixed plate heat exchanger manufacturer's written installation instructions.
- 2.23 AIR-HANDLING UNIT FACTORY REFRIGERANT PIPING AND PIPING INSULATION
- A. Refer to section 232300 "Refrigerant Piping" for refrigerant piping requirements and section 230719 "HVAC Piping Insulation" for piping insulation requirements.
- 2.24 DRAINS
- A. Floor Drains:
1. Drain Body: Fabricate floor drain body of NPS 4 or larger aluminum or stainless pipe and weld a plate of same material to the bottom. Option to fabricate an aluminum or stainless steel rectangular box drain at least 4 by 4 inches of material at least 0.1 inch thick.
 2. Drain Connection: Weld a nominal NPS 2 half coupling in side of drain body located within 1 inch from bottom.
 3. Drain Cover: Perforated plate, at least 0.1 inch thick, or grating, fabricated from aluminum or stainless steel. Drain cover shall be supported and secured in place by drain body, but not fastened to drain body with fasteners.
 4. Fluid Seal: Weld floor drain body to air-handling unit floor for a watertight installation.
 5. Mounting: Recess floor drain body into structural base. Top of floor drain to be slightly recessed below air-handling unit finished floor for unobstructed gravity flow from floor into drain.
 6. Application:
 - a. Install floor drains in air-handling unit floors of coil, heat wheel, heat exchanger, and associated access sections.
- 2.25 FACTORY ASSEMBLED ELECTRICAL
- A. Factory install service light fixtures and switches, and receptacles for each air-handling unit.
1. Locate in a convenient and field-accessible location.
 2. Installation shall comply with NFPA 70.

3. Wire, Conduit, and Enclosures:
 - a. Minimum Conduit Size: 3/4 inch.
 - b. Materials: Metal, with a corrosion-resistant finish.
 - c. Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware.
 - d. Conduit: Locate conduit inside the air-handling unit casing. Conduit installed on exterior of air-handling unit casing is unacceptable.
 - e. Wire:
 - 1) Copper, rated for 600 V, solid wire for size No. 10 AWG and smaller and stranded wire for larger sizes.
 - 2) Minimum Wire Size: No. 12 AWG.
 - 3) Each circuit shall have a ground wire.
 - 4) Install wire in conduit.
 - f. Boxes, Conduit Outlet Bodies, and Enclosures:
 - 1) Located on Exterior of Air-Handling Unit Casing: NEMA 250, Type 4X.
 - g. Seals: Seal pathways to prevent air leakage between air-handling unit exterior and interior, and between internal component sections.
 - h. Service Lighting and Receptacle Applications:
 - 1) Factory install a main disconnect switch for interfacing air-handling power for service lighting with single-point field power wiring connection.
- B. Main Disconnect Switches: Factory-install main disconnect switch mounted on air-handling unit casing exterior for interface of factory power wiring with field power wiring.
 1. Specification Grade: "Heavy Duty Type"; "quick-make," "quick-break" construction.
 2. Three pole, nonfused.
 3. 600 V rated.
 4. Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than 65,000 A.
 5. Enclosure:
 - a. Located on Exterior of Air-Handling Unit Casing: NEMA 250, Type 4X.
 6. Operating handle shall be of box-mounted type that directly drives switch mechanism.
 7. Disconnect switch shall use a flange-operated visible blade that is close coupled to a vertical-lift-type handle that achieves a positive visible indication of disconnect with cover open or closed.
 8. Disconnect switch shall have a defeatable, front-accessible, mechanical interlock to prevent opening of cover when switch is in "ON" position, and to prevent turning switch "ON" when the door is open.
 9. Include a solid neutral as required by authorities having jurisdiction.
 10. Disconnect switch shall have a ground lug for ground wire termination.
 11. Operating handle shall be lockable in open position.
 12. Horsepower rated.
 13. Feed through or double lugged.
- C. Interior Service Light Fixtures:
 1. LED Luminaires:
 - a. Suitable for wet locations and operation in cold- and hot-temperature extremes encountered; dust and moisture resistant.
 - b. High-impact, UV-stabilized fiberglass housing and acrylic lens.
 - c. Light Color: 3500 K.
 - d. Light Output: 3000 lumens.
 - e. Driver: 1 percent dimming.
- D. Toggle Switches for Service Light Fixtures:
 1. Single-Pole Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.
 2. Two-Pole Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.

3. Three-Way Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.
 4. Four-Way Switches, 120/277 V, 20 A: Comply with UL 20 and FS W-S-896.
 5. Lighted Single-Pole Switches, 120/277 V, 20 A: Comply with NEMA WD 1, UL 20, and FS W-S-896.
 - a. Description: Handle illuminated when switch is on.
 6. Toggle Switch Box and Cover: Mount toggle switch in a cast-aluminum outlet box with cast-aluminum cover. Weatherproof where exposed to outdoors.
 7. Application:
 - a. Factory install switching configuration (single, three way, or four way) required to operate a single service light fixture or group of service light fixtures from any access door that opens to respective service light fixtures.
 - b. Factory install a single service light switch to switch all service light fixtures from a single location.
 8. Switches with Lighted Handles Applications: Lighted handle feature may be omitted where on/off status of internal lights can be viewed through an access door window.
- E. Receptacles:
1. Duplex GFCI Receptacles, 125 V, 20 A:
 - a. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
 - b. Configuration: NEMA WD 6, Configuration 5-20R.
 - c. Type: Non-feed through.
 - d. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.
 2. Receptacle Box and Cover: Mount receptacle in a cast-aluminum outlet box with cast-aluminum cover. Weatherproof where exposed to outdoors.
 3. Applications: Factory install a receptacle in a convenient and field-accessible location on air-handling unit exterior of casing.
- F. Power Supply to Fan Motors:
1. Factory install a variable-frequency controller for each fan motor.
 - a. Locate in a convenient and field-accessible location on unit exterior.
 - b. Installation shall comply with NFPA 70.
 - c. Wire, Conduit, and Enclosures:
 - 1) Minimum Conduit Size: 3/4 inch.
 - 2) Materials: Metal, corrosion resistant.
 - 3) Motor Termination: Flexible conduit, NRTL listed, not to exceed 36 inches long.
 - 4) Supports: Support conduits, boxes, and enclosures using corrosion-resistant fastening hardware.
 - 5) Wire:
 - a) Copper, rated for 600 V, solid wire for size No. 10 AWG and smaller and stranded wire for larger sizes.
 - b) Minimum Wire Size: No. 12 AWG.
 - c) Each circuit shall have a ground wire.
 - d) Install wire in conduit.
 - d. Boxes, Conduit Outlet Boxes, and Enclosures:
 - 1) Located in Airstream: NEMA 250, Type 4.
 - 2) Located on Exterior of Air-Handling Unit Casing: NEMA 250, Type 4X.
- G. Variable-Frequency Controllers:
1. Description: NEMA ICS 2; arranged to achieve motor variable speed by adjusting output voltage and frequency.
 2. Enclosure: Unit mounted, with hinged full-front access door with lock and key.
 - a. Located in Service Corridor: NEMA 250, Type 4.
 - b. Located on Exterior of Air-Handling Unit Casing: NEMA 250, Type 4X.

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3. Externally Operated Disconnect: Door-Interlocked, Fused disconnect switch with lockable handle.
4. Minimum Short-Circuit Current Rating: As required by electrical power distribution system, but not less than 65,000 A.
5. Technology: Pulse-width-modulation (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.
6. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
7. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
8. Output signal shall be programmed to not cause mechanical vibration issues with fan drive assembly.
9. Operating Requirements:
 - a. Input AC Voltage Tolerance: 10 percent.
 - b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
 - c. Capable of driving full motor load, without derating.
 - d. Minimum Efficiency: 96 percent at 60 Hz, full load.
 - e. Minimum Displacement Primary-Side Power Factor: 95 percent.
 - f. Overload Capability: 1.05 times the full-load current for 7 seconds.
 - g. Starting Torque: As required by fan and motor drive assembly.
 - h. Speed Regulation: 1 percent.
 - i. Speed Range: 10:1 speed range.
 - j. To avoid equipment resonant vibrations, include critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
 - k. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
10. Controller Adjustability Capabilities: Minimum and maximum output frequency, acceleration and deceleration, and current limit.
11. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or need for replacement:
 - a. Surge suppression.
 - b. Loss of input signal protection.
 - c. Critical frequency rejection.
 - d. Overtemperature.
 - e. Short circuit at controller output.
 - f. Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.
 - g. Open circuit at controller output.
 - h. Input undervoltage.
 - i. Input overvoltage.
 - j. Loss of input phase.
 - k. Reverse phase.
 - l. AC line switching transients.
 - m. Instantaneous overload, line to line or line to ground.
 - n. Sustained overload exceeding 100 percent of controller rated current.
 - o. Starting a rotating motor.
12. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
13. Automatic Reset and Restart:
 - a. Capable of multiple restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.
 - b. Capable of automatic restart on phase-loss and overvoltage and undervoltage trips.
14. Visual Indication: On face of controller; indicating the following conditions:

- a. Power on.
 - b. Run.
 - c. Overcurrent and overvoltage.
 - d. Motor speed (percentage).
 - e. Various faults with alarm status.
 - f. Input kilovolt amperes.
 - g. Power factor.
 - h. Input kilowatts and kilowatt-hours.
 - i. Three-phase input and output voltage.
 - j. Three-phase input and output current.
 - k. Output frequency.
 - l. Elapsed operating time (hours).
 - m. Diagnostic and service parameters.
15. Operator Interface: Start-stop and auto-manual selector with manual-speed-control potentiometer.
16. Hardwired Control Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4 to 20 mA) and four programmable digital inputs.
17. Remote Communication Interface: ASHRAE 135 BACnet MS/TP>.
18. Line Conditioning:
- a. Input line conditioning.
 - b. Output filtering.
 - c. EMI/RFI filtering.
19. Bypass Controller:
- a. Bypass Controller/Variable-Frequency Controller Selector Switch: Include manual selector switch on face of enclosure for local operator control of preferred controller.
 - b. Bypass Mode: Manual operation only.
 - c. Type: Integrated NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller to operate fan motor if variable-frequency controller is not operational.
 - d. Arrangement: Configure power supply to bypass controller and variable-frequency controller to completely isolate power to variable-frequency controller while operating fan motor through bypass controller for safe servicing of variable-frequency controller.
 - e. Enclosure: Install bypass controller in same enclosure as variable-frequency controller.
 - f. Remote Monitoring: Include control relay for remote indication of bypass controller operation.

2.26 FACTORY-ASSEMBLED CONTROLS

A. General:

- 1. Air-handling unit manufacturer shall furnish pathways and allocate space for field installation of controls raceways and devices and install the following control instruments:
 - a. Flow station and flow transmitter for each fan.
 - b. Energy recovery wheel outdoor air, supply air, return air, and exhaust air temperature sensors, and VFD. All sensors shall be pre-assembled on the wheel and linked to a single junction box with a quick connect AMP/MOLEX type connector.

2.27 HARDWARE

A. Screws:

1. For Galvanized-Steel Materials: Self-tapping, hex-head, zinc-plate steel or 300 series stainless steel screws with a neoprene gasket encapsulated by a zinc-plate steel or 300 series stainless steel washer.
 2. For Aluminum and Stainless Steel Materials: Self-tapping, hex-head, 300 series stainless steel screws with a neoprene gasket encapsulated by a 300 series stainless steel washer.
 3. Provide protective covers on exposed screws to prevent personnel injury.
- B. Bolts, Nuts, and Washers:
1. For Joining Galvanized and Painted Carbon-Steel Materials: Hex-head, high-strength, galvanized steel or 300 series stainless steel.
 2. For Joining Aluminum and Stainless Steel Materials: Hex-head, high-strength, 300 series stainless steel.
 3. Use washers and lock washers at each bolted connection.
 4. Select bolt size and spacing sufficient for load and application.

2.28 WELDING

- A. Welding Filler Metals: Comply with AWS welding codes for welding materials appropriate for thickness and chemical analysis of material being welded.
1. Use welding materials with corrosion properties equal to material being welded.
- B. Use welders that are certified to weld at least the thickness of the material to be welded. Certification shall be within six months of work being performed.
- C. Welds shall be continuous, full-penetration welds unless otherwise indicated. Intermittent welds, stitch welds and tack welds are permitted only in specific applications indicated.
- D. Use welders and welding procedures complying with the following:
1. Piping Systems: Section IX of the ASME Boiler and Pressure Vessel Code and Section V of ASME B31.1.
 2. Structural Aluminum: AWS D1.2/D1.2M.
 3. Structural Carbon Steel: AWS D1.1/D1.1M.
 4. Structural Stainless Steel: AWS D1.6/D1.6M.
 5. Sheetmetal: AWS D9.1/D9.1M.

2.29 PAINTING

- A. General:
1. Painted OEM components do not require additional coating other than touch-up to damaged areas. Match the touchup coating to surrounding undamaged surfaces.
 2. Finish miscellaneous surfaces to match continuous surfaces.
 3. Protect mill galvanized surfaces that are exposed to view, such as raw steel cuts and damage by welding, with multiple coats of matching galvanized paint.
 4. Protect mill galvanized surfaces that are concealed, such as raw steel cuts and damage by welding, with multiple coats of zinc-rich paint or matching galvanized paint.
 5. Touch up or entirely repaint surface finishes, damaged during shipment and installation, to the original condition, using original materials and methods.
- B. Preparation:
1. Submit proposed manufacturer's written preparation and application instructions for information.
 2. If paint manufacturer's recommended preparation requirements differ from those indicated, use the more stringent requirements.

3. Structural carbon steel to be painted shall be deburred, ground smooth, cleaned, and blasted in accordance with SSPC-SP 6/NACE No. 3.
4. Before applying a primer and a finish coat, remove oil and grease from surfaces to be coated using clean rags soaked in thinner in accordance with SSPC-SP 1.
5. Treat surfaces to be painted to ensure that paint adheres.

C. Primer:

1. Rust-inhibiting type, with a minimum dry film thickness of 2 mil(s) per coat.
2. Apply at least two coats of primer to unfinished carbon-steel surfaces and at least one coat of primer to other surfaces.
3. Use primer that is compatible with substrate and finish coat.

D. Finish Coat:

1. Finish coat painting system shall be epoxy.
2. Use dry film thickness recommended by paint manufacturer for each coat. Total dry film thickness of all finish coats not less than 3 mils.
3. Painted Surfaces Minimum Properties:
 - a. Salt Spray ASTM B117: 5 percent salt solution fog at 95 deg F for 2000 hours with no deterioration.
 - b. Adhesion, ASTM D3359: When the coating is cut into 0.0625-inch squares and 3M No. 600 tape is suddenly removed, there is no loss of adhesion.
 - c. Humidity Resistance ASTM D2247: 850-hour exposure to 100 deg F and at least 95 percent relative humidity with no effect.
 - d. Pencil Hardness ASTM D3363: A hardness of 1H.
4. Finish coat color shall be selected by Architect and not be limited to manufacturer's standard offering.
 - a. Submit a written request for color selection and indicate in the request the date color selection must be returned without impacting schedule.

E. Application: Paint the following surfaces with primer and finish coat indicated:

1. Unfinished carbon-steel surfaces.
2. Exposed mill galvanized-steel surfaces of air-handling unit casing exterior.

2.30 CLEANLINESS REQUIREMENTS

A. General:

1. Provide equipment that has been manufactured, shipped, stored, and installed maintaining highest degree of cleanliness possible.

B. During Manufacturing:

1. Clean materials to be free of mill grease, oxidation, dirt, dust, and other impurities before manufacturing and assembly.
2. Protect casing materials from contamination during manufacturing and assembly.
3. Use sealing materials that do not outgas.
4. Provide OEM components and equipment from their respective manufacturers free of grease, oxidation, and dirt. Store OEM components and equipment indoors. Cover and protect OEM components and equipment to maintain cleanliness. Follow OEM instructions for equipment storage.

C. After Manufacturing:

1. Before shipment, after unit is completely assembled, clean unit inside and out.
 - a. Vacuum entire inside to remove dirt, dust, and debris using HEPA-filtered vacuum equipment.
 - b. Purge hard to reach surfaces with dry, oil-free, compressed or bottled nitrogen.
 - c. Wipe down all surfaces, inside and out, with a residue-free cleaning agent.

2. Protect unit to maintain cleanliness.

D. Shipping:

1. Protect interior and exterior of air-handling unit from exposure to weather dirt, dust, and debris during shipment and rigging.
2. Cover openings with puncture-resistant durable coverings to ensure that cleanliness is maintained inside unit while providing an air- and watertight seal.

E. On-Site Storage:

1. If air-handling unit is to be stored before installation, Installer shall work closely with air-handling unit manufacturer for air-handling unit manufacturer to provide adequate protection at the factory to ensure that cleanliness for both unit interior and unit exterior is maintained. This protection shall remain in place until unit startup is performed.
2. For extended periods of storage, provide a means to rotate fan and motor assemblies on a periodic basis (as recommended in writing by manufacturer) without compromising unit cleanliness.

2.31 SOURCE QUALITY CONTROL

A. AHRI Compliance:

1. AHRI 260 (I-P): Air-handling unit sound ratings shall be in accordance with AHRI 260 (I-P), "Sound Rating of Ducted Air Moving and Conditioning Equipment."
2. AHRI 410: Air-handling unit coils shall be rated in accordance with AHRI 410 and shall be listed by AHRI.
3. AHRI 1060 (I-P) Certification: Air-handling units that include energy wheels and fixed plate heat exchangers shall be rated in accordance with AHRI 1060 (I-P) and shall be listed by AHRI.

B. AMCA Compliance:

1. AMCA 201: Air-handling unit manufacturer shall evaluate fan's performance within the air-handling unit in accordance with AMCA 201, "Fans and Systems" and account for conditions within the air-handling unit that could be detrimental to fan's performance by adjusting the fan performance indicated on Drawings.
2. AMCA 205 Certification: Air-handling unit fan's fan efficiency grade (FEG) shall be rated in accordance with AMCA 205, "Energy Efficiency Classifications for Fans" and shall bear the AMCA-certified fan efficiency grade seal.
3. AMCA 210 Certification: Air-handling unit fan's air performance shall be rated in accordance with AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating".
4. AMCA 300: Air-handling unit fan's sound performance shall be rated in accordance with AMCA 300, "Reverberant Room Method for Sound Testing of Fans."
5. AMCA 500-D: Air-handling unit damper's performance shall be rated in accordance with AMCA 500-D, "Laboratory Methods of Testing Dampers for Rating".

C. NFPA Compliance:

1. NFPA 70: Electrical components, devices, and accessories shall be listed and labeled by a qualified testing agency, and marked for intended location and application.
2. NFPA 90A: Design, fabrication, and installation of air-handling units and components shall comply with NFPA 90A.

D. UL Compliance:

1. UL 1598 Certification: Air-handling unit UVGI shall be NRTL listed and labeled in accordance with UL 1598, "Luminaires."

2. UL 1995 Certification: Where indicated, air-handling unit components shall be NRTL listed and labeled in accordance with UL 1995, "Standard for Safety Heating and Cooling Equipment."

2.32 SOURCE QUALITY CONTROL - INDEPENDENT LABORATORY TESTING

A. General:

1. Project-specific testing by an independent laboratory is not required if air-handling unit manufacturer has written independent laboratory test results of past tests performed on same casing construction proposed for use on this Project.
2. If Project-specific testing is required, testing shall be performed in ample time to include test reports with submittals and before manufacturing of air-handling units. Include sufficient lead time for unit delivery, installation, and testing required by construction schedule.

B. Casing Structural Deflection Test:

1. Include service of an independent testing laboratory to verify casing structural deflection requirements indicated.
 - a. In lieu of independent laboratory testing, manufacturer may perform factory deflection testing of proposed construction to prove compliance.
2. Test proposed construction of walls, floor, and roof. Include a separate test for each unique casing construction proposed.
3. Submit test reports for each test to show compliance with performance indicated.

2.33 SOURCE QUALITY CONTROL - AIR-HANDLING UNIT FACTORY TESTS

A. Casing Leakage Test:

1. Perform a leak test for each assembled air-handling unit.
2. Follow testing procedures in accordance with ASHRAE 111.
3. Perform leak test before shipping first air-handling unit.
4. Test results shall indicate that units comply with leakage requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
5. Prepare test reports in accordance with ASHRAE 111.
6. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

B. Casing Structural Deflection Test:

1. Perform a structural deflection test for each assembled air-handling unit.
2. Pressurize and load air-handling units to the performance criteria indicated for structural deflection. Test air-handling unit floors, walls, and roofs.
3. Test results shall indicate that units comply with deflection requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
4. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

C. Functional Run Test:

1. Run test each unit before shipment.
2. Test and balance fans to comply with vibration requirements indicated.
3. Energize each electrical device to ensure it is operational.
 - a. Take meter readings for volts, amperes, and kVAr on each phase leg of each motor.
 - b. Take meter readings for volts, amperes, and kVAr on each single-phase power connection to field power.
4. Exercise each damper to ensure proper operation.
5. Exercise each access door to ensure proper fit.
6. Submit a written report for each unit tested. Written report shall include, at a minimum, full name of each person witnessing test, detailed list of each unit component tested, condition observed, and corrective action required. Each line item shall have full name of the person doing the checkout and date and time the checkout was performed.

D. Acoustical Performance Test:

1. Perform an acoustical performance test for each assembled air-handling unit.
2. Air-handling unit acoustic performance shall be verified by factory test in accordance with AHRI 260 (I-P) or AHRI 261 (SI).
3. Air-handling unit supply-air discharge, return-air inlet, and casing radiated sound components shall be measured with air-handling unit operating at design conditions.
4. Testing Location: Perform testing in a location complying with AHRI 220, "Reverberation Room Qualification and Testing Procedures for Determining Sound Power of HVAC Equipment."
 - a. Test location shall be broadband qualified in accordance with AHRI 220 Section 5.1 and discrete frequency qualified in accordance with Section 5.2.
5. Test results shall indicate that units comply with acoustical requirements indicated. Make changes to noncompliant air-handling units and retest until units comply with requirements.
6. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

E. Refrigerant Piping Systems Testing: Pressure test factory-assembled piping systems with nitrogen at a pressure recommended by the Variable Refrigerant System manufacturer, but not less than 1.25 times the design operating pressure..

1. Test results shall indicate that piping systems are without leaks. Make changes to noncompliant piping systems and retest until units comply with requirements.
2. Submit test reports indicating test location, documentation of test equipment used, test procedures, test results, test date and time, and full names of personnel performing tests and witnesses. If multiple tests are required to achieve compliance for a single air-handling unit, report shall include test date and time, test results, and full names of personnel performing tests and witnesses of each test with a detailed description and photographs of interim corrective measures made before each retest.

2.34 SOURCE QUALITY CONTROL - OEM COMPONENT FACTORY TESTS

A. Coil Testing:

1. Refrigerant Coils: Factory tested with air while coil is completely submerged underwater to design pressure indicated, but not less than 300-psig internal pressure.
2. Coils to display a tag with inspector's identification as proof of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine air-handling units before installation. Reject units with physical damage, and air-handling unit components that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for the following before installation of air-handling units:
 - 1. Structural substrate mounting and anchorage to verify actual sizes, types, and locations.
 - 2. Piping systems to verify actual sizes, types, and locations of connections.
 - 3. Ductwork and plenums to verify actual sizes, types, and locations of connections.
 - 4. Electrical services and controls to verify actual sizes, types, and locations of connections.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF OUTDOOR, CUSTOM AIR-HANDLING UNITS

- A. Equipment Mounting: Install air-handling units at locations indicated on Drawings. Unless, otherwise indicated on Drawings, install air-handling units on vibration isolation roof curbs.
 - 1. Install air-handling units on curbs following air-handling unit manufacturer's written procedures.
 - a. Install gaskets before setting air-handling units on curbs.
 - b. Secure air-handling units to curbs using stainless steel fasteners.
 - c. Install curb and fasten to structure.
 - d. Coordinate curb requirements, attachment, and location before installation.
- B. Roof Openings:
 - 1. Provide exact size and location of roof openings to trade installing structural framing and roof structure.
 - 2. Supervise framing of openings to ensure coordinated installation with air-handling units.
- C. Equipment Clearances and Access:
 - 1. Arrange installation of air-handling units to provide access space around air-handling units for service and maintenance and for removal and replacement of internal components.
 - 2. Provide clearance and access required by governing codes and NFPA 70.
 - 3. At a minimum, comply with requirements indicated on Drawings and air-handling unit manufacturer's written instructions.

3.3 PROTECTION DURING CONSTRUCTION

- A. Exterior Covers: Cover air-handling units during construction with sealed covers to protect air-handling unit casing and externally mounted components from physical damage, dirt, dust and debris, paint splatter, and any other construction materials.
 - 1. Minor physical damage, as determined by Owner, shall be repaired by air-handling unit factory service personnel to factory-finished condition.
 - 2. Replace air-handling units with damage that in any way compromises the performance indicated.
- B. Internal Access: Keep access doors locked to maximum extent possible and restrict access to only authorized personnel.

1. Open access doors only during periods authorized work inside air-handling units is required.
2. Coordinate and monitor work inside air-handling units on a shift basis. Lock access doors once work is complete or at the end of each shift.
3. Immediately report unauthorized access and any observed damage to Owner.

3.4 DUCT CONNECTIONS

- A. Connect ducts and plenums to air-handling unit connections. Comply with requirements in Section 233113 "Metal Ducts."
- B. Connect ducts and plenums to air-handling unit connections with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."
- C. Provide duct transitions required to make field connections to air-handling units.
- D. Arrange ducts and plenums to provide unobstructed access to inside of air-handling units.

3.5 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to air-handling unit, provide unobstructed access to inside of air-handling units for service and maintenance.
- C. Connect piping to air-handling units with flexible connectors.
- D. Cooling Coil Condensate Drain Pan Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping."
 1. Make connections to air-handling unit connections with flanges or unions.
 2. Extend dedicated cooling coil drain pan piping from each air-handling unit connection to nearest roof drain and arrange piping to maintain clear service aisle paths free of potential tripping hazards.
 3. Construct traps near air-handling unit connections to seal airflow from escaping within air-handling unit. Locate traps in a serviceable location that is away from access doors.
 4. Install threaded cleanouts at changes in direction.
 5. Secure drain piping to structure.
- E. Air-Handling Unit Floor Drains: Do not require installation of permanent drain piping.
- F. Refrigerant Coil Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping". Install shutoff valve at each supply and return connection.

3.6 ELECTRICAL CONNECTIONS

- A. Coordinate electrical connections with air-handling unit manufacturer and Division 26.
- B. Division 26 shall connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Division 26 shall ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.7 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 230923 "Direct Digital Control (DDC) System for HVAC."
- C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.8 STARTUP SERVICE

- A. Engage an air-handling unit factory service representative to perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Verify that shipping, blocking, and bracing are removed.
 - 3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, controls, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
 - 4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
 - 5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
 - 6. Verify that face-and-bypass dampers provide full face flow.
 - 7. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
 - 8. Comb coil fins for parallel orientation.
 - 9. Verify that proper thermal-overload protection is installed for electric heaters.
 - 10. Install new, clean filters.
 - 11. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
- B. Starting procedures for air-handling units include the following:
 - 1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.
 - 2. Measure and record motor electrical values for voltage and amperage.
 - 3. Manually operate dampers from fully closed to fully open position and record fan performance.
- C. Heat Wheel Startup Service:
 - 1. After field installation is complete, a final checkout and startup shall be completed to ensure proper purge adjustment, seal adjustment, control settings, and other key operational functions.
 - 2. Service shall be completed by trained factory service personnel employed by heat wheel manufacturer.
 - 3. Submit a report summarizing findings, adjustments made, and final settings.

3.9 ADJUSTING

- A. Adjust damper linkages for proper damper operation.

- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
- C. Before turning equipment over to Owner for use, adjust air-handling unit components that require further adjustment for proper operation. Consult air-handling unit manufacturer for instruction.
- D. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
- E. Seasonal Adjustments: Make seasonal visits during warranty period to inspect and review operation of equipment. Make necessary adjustments for components observed to require adjustments for proper operation. Prepare and submit a report to Owner documenting each visit, observations, and any adjustments made.

3.10 CLEANING

- A. Cleaning Schedule: After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems, and after completing startup service, and immediately before Owner use, clean air-handling units to remove foreign material and construction dirt and dust.
- B. Unit Interior: Clean air-handling units internally to factory clean condition. Remove foreign material and construction debris, dirt, and dust.
 - 1. Vacuum clean with HEPA-filtered vacuum and then wipe down with cleaning solution.
 - 2. Clean casing floors, roofs, wall surfaces, access doors, and panels.
 - 3. Clean all internal components, such as, coils, dampers, filter frames, fans, and motors.
 - 4. Clean light fixtures and control devices.
- C. Unit Exterior: Clean external surfaces of air-handling units to factory clean condition. Remove foreign material and construction debris, dirt and dust. Vacuum clean with HEPA-filtered vacuum and then wipe down all surfaces with cleaning solution.
- D. Cleaning Materials: Use cleaning materials and products recommended in writing by air-handling unit manufacturer.
- E. Acceptance: Following unit cleaning submit a written request for review and Owner acceptance. Acceptance for cleaning of air-handling units must pass a white glove test.

3.11 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Tests and Inspections: Perform the following tests and inspections.
 - 1. After field piping connections are complete, test coils and connections for leaks.
 - 2. Charge refrigerant coils with refrigerant and test for leaks.
 - 3. Field-Assembly Supervision: Instruct Installer and supervise field installation of air-handling unit(s) shipped in multiple pieces for field assembly.
 - 4. Roof-Mounted Field-Installation Supervision: Instruct Installer and supervise field installation of roof-mounted air-handling unit(s).

5. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.12 OPERATION DURING CONSTRUCTION

- A. Operation of air-handling units for temporary cooling, heating, and ventilation is not allowed without Owner authorization.
1. Submit written request for Owner approval by signature with detailed description of operating procedures to be followed including, but not limited to, the following:
 - a. Description of construction activities while units are operating.
 - b. Operation:
 - 1) Beginning and ending calendar dates.
 - 2) List each day during week.
 - 3) List start and stop time and hours for each day.
 - c. Startup procedures and shut-down procedures.
 - d. Provisions for routine monitoring of unit operation.
 - e. Provisions to prevent and protect against damage to equipment due to adverse operation such as, low temperature, high temperature, over pressure, fire, smoke, electrical over- and undervoltage and current and electrical fault.
 - f. Provisions and safeguards for filtration to keep inside of units from getting dirty.
 - g. Record keeping.
 2. If approved by Owner, units used for temporary cooling, heating, and ventilation during and before interior finish work is complete shall include an unconditional complete unit labor and parts warranty to extend at least [two] <Insert number> years after the warranty indicated expires.
 3. Interior and exterior of air-handling units shall be cleaned to a factory-cleaned condition and clean condition must be accepted by Owner.
- B. Filtration During Temporary Use:
1. Protect air-handling system ducts (exhaust air, outdoor air, and return air) with temporary filters installed and supported to prevent filter media from collapse and bypass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV 11 in accordance with ASHRAE 52.2.
 2. Protect air-handling units with open inlets that are not ducted with temporary filters installed and supported to prevent filter media from collapse and by-pass of unfiltered air. Temporary media shall be installed at each inlet and shall have a published filtration efficiency of MERV 11 in accordance with ASHRAE 52.2.
 3. Do not operate air-handling units until both temporary and scheduled permanent air-handling unit particulate filters are in place. Temporary filters must be installed upstream of permanent filters while units are operating.
 4. Replace temporary and permanent filters used during construction when dirty. After end of temporary use, replace permanent filters with new, clean filters before beginning testing, adjusting and balancing.
- C. Comply with SMACNA 008, "IAQ Guidelines for Occupied Buildings under Construction," for procedures to protect HVAC system.

3.13 DEMONSTRATION

- A. Engage air-handling unit manufacturer employed training instructor to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.
- B. Training shall include, but not be limited to, procedures and schedules related to performance, safety, startup and shut down, troubleshooting, servicing, preventive maintenance, and how to obtain replacement parts.
 - 1. Access Doors: Adjustment, gasket removal and replacement, handle removal and replacement, and spare parts.
 - 2. Access Panels: Removal and replacement, adjustment, gasket removal and replacement, and spare parts.
 - 3. Coils: Cleaning, combing fins, draining, venting, removal, and replacement.
 - 4. Controls: Calibration, cleaning, operation, service, removal and replacement, and spare parts.
 - 5. Damper Assemblies: Cleaning, operation, service, removal and replacement, and spare parts.
 - 6. Drain Pans: Cleaning, removal, and replacement.
 - 7. Electric Heaters: Cleaning, operation, service, removal and replacement, and spare parts.
 - 8. Heat Wheels: Cleaning, operation, service, removal and replacement, and spare parts.
 - 9. Fan and Motor Assemblies: Cleaning, operation, removal and replacement, service, and spare parts.
 - 10. Filters: Operation, removal and replacement, frame gasket removal and replacement, clip removal and replacement, and spare parts.
 - 11. Fixed Plate heat Exchangers: Cleaning, removal, and replacement.
 - 12. Lights, Receptacles and Switches: Cleaning, operation, service, removal and replacement, and spare parts.
- C. Instructor:
 - 1. Instructor shall be factory trained and certified by air-handling unit manufacturer with current training on equipment installed.
 - 2. Instructor's credentials shall be submitted for review by Architect and Commissioning Agent before scheduling training.
 - 3. Instructor(s) shall have not less than three years of training experience with air-handling unit manufacturer and past training experience on at least three projects of comparable size and complexity.
- D. Schedule and Duration:
 - 1. Schedule training with Owner at least 20 business days before first training session.
 - 2. Training shall occur before Owner occupancy.
 - 3. Training shall be held at mutually agreed date and time during normal business hours.
 - 4. Each training day shall not exceed eight hours of training. Daily training schedule shall allow time for a one-hour lunch period and 15 minute break after every two hours of training at a minimum..
 - 5. Perform not less than eight hours of training.
- E. Location: Owner to provide a suitable on-site location to host classroom training.
- F. Training Attendees: Assume six people.
- G. Training Attendance Records: For record purposes, document training attendees at start of each new training session. Record date, time, brief description of training covered during the session, attendee's name, signature, phone number, and e-mail address. Submit scanned copy of sign-in sheet to Owner for each training session.

- H. Training Format: Individual training modules to include classroom training followed by hands-on field demonstration and training.
- I. Training Materials: Provide training materials in electronic format to each attendee.
 - 1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
- J. Training Video Recording: Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.
- K. Written Acceptance: Obtain Commissioning Agent or Owner written acceptance that training is complete and requirements indicated have been satisfied.

END OF SECTION

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SECTION 238126

SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. LEED Submittals:
 - 1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.
- D. Samples for Initial Selection: For units with factory-applied color finishes.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set for each air-handling unit.
2. Gaskets: One set for each access door.
3. Fan Belts: One set for each air-handling unit fan.

1.7 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE Compliance:
 1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
 2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Procedures," and Section 7 - "Construction and System Start-up."
- C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.8 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."
- B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
 1. Warranty Period:
 - a. For Compressor: Five year(s) from date of Substantial Completion.
 - b. For Parts: One year from date of Substantial Completion.
 - c. For Labor: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Lennox Industries, Inc. ; Lennox International.
 2. Mitsubishi Electric & Electronics USA, Inc.
 3. Daikin.
 4. LG.

2.2 INDOOR UNITS (5 TONS OR LESS)

A. Wall-Mounted, Evaporator-Fan Components:

1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
3. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements; with refractory ceramic support bushings, automatic-reset thermal cutout, built-in magnetic contactors, manual-reset thermal cutout, airflow proving device, and one-time fuses in terminal box for overcurrent protection.
4. Fan: Direct drive, centrifugal.
5. Fan Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
 - c. Enclosure Type: Totally enclosed, fan cooled.
 - d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
 - e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 - f. Mount unit-mounted disconnect switches on interior of unit.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
7. Condensate Drain Pans:
 - a. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
 - 1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
 - 2) Depth: A minimum of 1 inch> deep.
 - b. Single-wall, stainless-steel sheet.
 - c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
 - 1) Minimum Connection Size: NPS 1.
 - d. Pan-Top Surface Coating: Asphaltic waterproofing compound.
 - e. Condensate Pump: Integral condensate pump (prewired).
8. Air Filtration Section:
 - a. General Requirements for Air Filtration Section:
 - 1) Comply with NFPA 90A.
 - 2) Minimum Arrestance: According to ASHRAE 52.1 and MERV according to ASHRAE 52.2.

- 3) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

b. Washable Filters:

- 1) Factory-fabricated, cold catalyst filter.

2.3 OUTDOOR UNITS (5 TONS OR LESS)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - a. Compressor Type: Scroll.
 - b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
 - c. Refrigerant Charge: R-410A.
 - d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.
3. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.
6. Low Ambient Kit: Permits operation down to 45 deg F.
7. Mounting Base: Polyethylene.

2.4 ACCESSORIES

- A. Control equipment and sequence of operation are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- B. Thermostat: Low voltage with subbase to control compressor and evaporator fan with the following features:
 1. Compressor time delay.
 2. 24-hour time control of system stop and start.
 3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
 4. Fan-speed selection including auto setting.
- C. Automatic-reset timer to prevent rapid cycling of compressor.
- D. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
- E. Drain Hose: For condensate.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install units level and plumb.
- B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- C. Install roof-mounted, compressor-condenser components on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.
- D. Equipment Mounting:
 - 1. Install ground-mounted, compressor-condenser components on equipment curbs as indicated on the drawings.
 - 2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.4 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION

SECTION 238129

VARIABLE-REFRIGERANT-FLOW HVAC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes complete VRF HVAC system(s) including, but not limited to, delegated design and the following components to make a complete operating system(s) according to requirements indicated:

1. Indoor, concealed, ceiling-mounted units for ducting.
2. Indoor, recessed, ceiling-mounted units.
3. Outdoor, air-source heat recovery units.
4. Heat recovery control units.
5. System controls.
6. System refrigerant and oil.
7. System refrigerant piping.
8. System condensate drain piping.
9. Metal hangers and supports.
10. Metal framing systems.
11. Fastener systems.
12. Pipe stands.
13. Miscellaneous support materials.
14. Piping and tubing insulation.
15. System control cable and raceways.

1.3 DEFINITIONS

- A. Air-Conditioning System Operation: System capable of operation with all zones in cooling only.
- B. Heat-Pump System Operation: System capable of operation with all zones in either heating or cooling, but not with simultaneous heating and cooling zones that transfer heat between zones.
- C. Heat Recovery System Operation: System capable of operation with simultaneous heating and cooling zones that transfer heat between zones.
- D. HRCU: Heat Recovery Control Unit. HRCUs are used in heat recovery VRF HVAC systems to manage and control refrigerant between indoor units to provide simultaneous heating and cooling zones. "Heat Recovery Control Unit" is the term used by ASHRAE for what different manufacturers term as branch circuit controller, branch selector box, changeover box, flow selector unit, mode change unit, and other such terms.
- E. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

- F. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.
- G. Three-Pipe System Design: One high pressure refrigerant vapor line, one low pressure refrigerant vapor line, and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One liquid line and refrigerant vapor line connect HRCUs to associated indoor units.
- H. Two-Pipe System Design: One refrigerant vapor line and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One refrigerant liquid line and refrigerant vapor line connect HRCUs to associated indoor units. HRCUs used in two pipe systems act as an intermediate heat exchanger and include diverting valves and gas/liquid separators to move high- and low-pressure refrigerant between indoor units.
- I. VRF: Variable refrigerant flow.

1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.

- 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for indoor and outdoor units and for HRCUs.
- 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- 3. Include operating performance at design conditions and at extreme maximum and minimum outdoor ambient conditions.
- 4. Include description of system controllers, dimensions, features, control interfaces and connections, power requirements, and connections.
- 5. Include system operating sequence of operation in narrative form for each unique indoor- and outdoor-unit and HRCU control.
- 6. Include description of control software features.
- 7. Include total refrigerant required and a comprehensive breakdown of refrigerant required by each system installed.
- 8. Include refrigerant type and data sheets showing compliance with requirements indicated.
- 9. For system design software.
- 10. Indicate location and type of service access.

- B. Shop Drawings: For VRF HVAC systems.

- 1. Include plans, elevations, sections, and mounting details.
- 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- 3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
- 4. Include diagrams and details of refrigerant piping and tubing showing installation requirements for manufacturer-furnished divided flow fittings.

5. Include diagrams for power, signal, and control wiring.

C. Delegated-Design Submittals:

1. Include design calculations for selecting vibration isolators and for designing vibration isolation bases.
2. Include design calculations with corresponding diagram of refrigerant piping and tubing sizing for each system installed.
3. Include design calculations with corresponding floor plans indicating that refrigerant concentration limits are within allowable limits of ASHRAE 15 and governing codes.
4. Include calculations showing that system travel distance for refrigerant piping and controls cabling are within horizontal and vertical travel distances set by manufacturer. Provide a comparison table for each system installed.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, sections, and details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural floors, roofs and associated members to which equipment, piping, ductwork, cables, and conduit will be attached.
3. Size and location of initial access modules for acoustical tile.
4. Wall-mounted controllers located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.
5. Size and location of access doors and panels installed behind walls and inaccessible ceilings for products installed behind walls and requiring access.
6. Items penetrating finished ceiling including the following:
 - a. Luminaires.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Service access panels.

B. Qualification Data:

1. For Installer: Certificate from VRF HVAC system manufacturer certifying that Installer has successfully completed prerequisite training administered by manufacturer for proper installation of systems, including but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
 - a. Retain copies of Installer certificates on-site and make available on request.
2. For VRF HVAC system manufacturer.
3. For VRF HVAC system provider.

C. Product Test Reports: Where tests are required, for each product, for tests performed by a qualified testing agency.

D. Source quality-control reports.

E. Field quality-control reports.

- F. Sample Warranties: For manufacturer's warranties.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For VRF HVAC systems to include in emergency, operation, and maintenance manuals.
- B. Software and Firmware Operational Documentation:
1. Software operating and upgrade manuals.
 2. Program Software Backup: On CD or DVD, USB media, or approved cloud storage platform, complete with data files.
 3. Device address list.
 4. Printout of software application and graphic screens.

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Filters:
 - a. One set(s) for each unit with replaceable filters.
 - b. One set(s) for each unit type and unique size of washable filters.

1.9 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
1. Nationally recognized manufacturer of VRF HVAC systems and products.
 2. Shipped VRF HVAC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
 3. VRF HVAC systems and products that have been successfully tested and in use on at least five completed projects.
 4. Having complete published catalog literature, installation, and operation and maintenance manuals for all products intended for use.
 5. Having full-time in-house employees for the following:
 - a. Product research and development.
 - b. Product and application engineering.
 - c. Product manufacturing, testing, and quality control.
 - d. Technical support for system installation training, startup, commissioning, and troubleshooting of installations.
 - e. Owner training.
- B. Factory-Authorized Service Representative Qualifications:
1. Authorized representative of, and trained by, VRF HVAC system manufacturer.
 2. In-place facility located within 50 miles of Project.
 3. Demonstrated past experience with products being installed for period within three consecutive years before time of bid.
 4. Demonstrated past experience on five projects of similar complexity, scope, and value.
 - a. Each person assigned to Project shall have demonstrated past experience.

5. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
 6. Service and maintenance staff assigned to support Project during warranty period.
 7. Product parts inventory to support ongoing system operation for a period of not less than five years after Substantial Completion.
 8. VRF HVAC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.
- C. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by VRF HVAC system manufacturer.
1. Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
 2. Installer certification shall be valid and current for duration of Project.
 3. Retain copies of Installer certificates on-site and make available on request.
 4. Each person assigned to Project shall have demonstrated past experience.
 - a. Demonstrated past experience with products being installed for period within three consecutive years before time of bid.
 - b. Demonstrated past experience on five projects of similar complexity, scope, and value.
 5. Installers shall have staffing resources of competent, trained, and experienced full-time employees that are assigned to execute work according to schedule.
- D. ISO Compliance: System equipment and components furnished by VRF HVAC system manufacturer shall be manufactured in an ISO 9001 and ISO 14001 facility.
- 1.10 DELIVERY, STORAGE, AND HANDLING
- A. Deliver and store products in a clean and dry place.
 - B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.
 - C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.
 - D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
 1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
 2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
 - E. Replace installed products damaged during construction.
- 1.11 WARRANTY
- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace equipment and components that fail(s) in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
 - a. Structural failures.
 - b. Faulty operation.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.
2. Warranty Period:
 - a. For Compressor: 10 year(s) from date of Substantial Completion.
 - b. For Parts, Including Controls: Five year(s) from date of Substantial Completion.
 - c. For Labor: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. LG.
 2. Daikin AC (Americas), Inc.
 3. Mitsubishi
- B. Source Limitations: Obtain products from single source from single manufacturer including, but not limited to, the following:
 1. Indoor and outdoor units, including accessories.
 2. Controls and software.
 3. HRCUs.
 4. Specialty refrigerant pipe fittings.
 5. Air Handling Unit Control Kit

2.2 SYSTEM DESCRIPTION

- A. Direct-expansion (DX) VRF HVAC system(s) with variable capacity in response to varying cooling and heating loads. System shall consist of multiple indoor units, HRCUs, outdoor unit(s), piping, controls, and electrical power to make complete operating system(s) complying with requirements indicated.
 1. Three-pipe system design.
 2. System(s) operation, heat recovery as indicated on Drawings.
 3. Each system with one refrigerant circuit shared by all indoor units connected to system.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. AHRI Compliance: System and equipment performance certified according to AHRI 1230, and products listed in AHRI directory.
- D. ASHRAE Compliance:
 1. ASHRAE 15: For safety code for mechanical refrigeration.
 2. ASHRAE 62.1: For indoor air quality.

3. ASHRAE 135: For control network protocol with remote communication.
4. ASHRAE/IES 90.1 Compliance: For system and component energy efficiency.

E. UL Compliance: Comply with UL 1995.

2.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer or specialist, as defined in Section 014000 "Quality Requirements," to design complete and operational VRF HVAC system(s) complying with requirements indicated.

1. Provide system refrigerant calculations.
 - a. Refrigerant concentration limits shall be within allowable limits of ASHRAE 15 and governing codes.
 - b. Indicate compliance with manufacturer's maximum vertical and horizontal travel distances. Prepare a comparison table for each system showing calculated distances compared to manufacturer's maximum allowed distances.
2. Include a mechanical ventilation system and gas detection system as required to comply with ASHRAE 15 and governing codes.
3. System Refrigerant Piping and Tubing:
 - a. Arrangement: Arrange piping to interconnect indoor units, HRCUs, and outdoor unit(s) in compliance with manufacturer requirements and requirements indicated.
 - b. Routing: Conceal piping above ceilings and behind walls to maximum extent possible.
 - c. Sizing: Size piping system, using a software program acceptable to manufacturer, to provide performance requirements indicated. Consider requirements to accommodate future change requirements.
4. System Controls:
 - a. Network arrangement.
 - b. Network interface with other building systems.
 - c. Product selection.
 - d. Sizing.

B. Service Access:

1. Provide and document service access requirements.
2. Locate equipment, system isolation valves, and other system components that require service and inspection in easily accessible locations. Avoid locations that are difficult to access if possible.
3. Where serviceable components are installed behind walls and above inaccessible ceilings, provide finished assembly with access doors or panels to gain access. Properly size the openings to allow for service, removal, and replacement.
4. If less than full and unrestricted access is provided, locate components within an 18-inch reach of the finished assembly.
5. Where ladder access is required to service elevated components, provide an installation that provides for sufficient access within ladder manufacturer's written instructions for use.
6. Comply with OSHA regulations.

- C. System Design and Installation Requirements:
1. Design and install systems indicated according to manufacturer's recommendations and written instructions.
 2. Where manufacturer's requirements differ from requirements indicated, contact Architect for direction. The most stringent requirements should apply unless otherwise directed in writing by Architect.
- D. System Adaptability to Future Changes: Arrange and size system refrigerant piping to accommodate future changes to system without having to resize and replace existing refrigerant piping.
1. Future changes to system(s) indicated on Drawings.
- E. Isolation of Equipment: Provide isolation valves to isolate each HRCU, indoor unit and outdoor unit for service, removal, and replacement without interrupting system operation.
- F. System Capacity Ratio: The sum of connected capacity of all indoor units shall be within the following range of outdoor unit rated capacity:
1. Not less than 60 percent.
 2. Not more than 130 percent.
 3. Range acceptable to manufacturer.
- G. System Turndown: Stable operation down to 20 percent of outdoor-unit capacity.
- H. System Auto Refrigerant Charge: Each system shall have an automatic refrigerant charge function to ensure the proper amount of refrigerant is installed in system.
- I. Outdoor Conditions:
1. Suitable for outdoor ambient conditions encountered.
 - a. Design equipment and supports to withstand wind loads of governing code and ASCE/SEI7.
 - b. Design equipment and supports to withstand snow and ice loads of governing code and ASCE/SEI 7.
 - c. Provide corrosion-resistant coating for components and supports where located in coastal or industrial climates that are known to be harmful to materials and finishes.
 2. Maximum System Operating Outdoor Temperature: See Drawings.
 3. Minimum System Operating Outdoor Temperature: See Drawings.
- J. Sound Performance: Sound levels generated by operating HVAC equipment shall be within requirements indicated.
1. Indoor: See Drawings.
 2. Outdoor: See Drawings.
- K. Thermal Movements: Allow for controlled thermal movements from ambient, surface, and system temperature changes.
- L. Capacities and Characteristics: As indicated on Drawings.

2.4 INDOOR, CONCEALED, CEILING-MOUNTED UNITS FOR DUCTING

- A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.
- B. Cabinet:
 - 1. Material: Galvanized or painted steel.
 - 2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
 - 3. Duct Connections: Extended collar or flange, or designated exterior cabinet surface, designed for attaching field-installed ductwork.
 - 4. Mounting: Manufacturer-designed provisions for field installation.
 - 5. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- C. DX Coil Assembly:
 - 1. Coil Casing: Aluminum, galvanized, or stainless steel.
 - 2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
 - 3. Coil Tubes: Copper, of diameter and thickness required by performance.
 - 4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
 - 5. Unit Internal Tubing: Copper tubing with brazed joints.
 - 6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 - 7. Field Piping Connections: Manufacturer's standard.
 - 8. Factory Charge: Dehydrated air or nitrogen.
 - 9. Testing: Factory pressure tested and verified to be without leaks.
- D. Drain Assembly:
 - 1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
 - 2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
 - 3. Field Piping Connection: Non-ferrous material with threaded NPT.
- E. Fan and Motor Assembly:
 - 1. Fan(s):
 - a. Direct-drive arrangement.
 - b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
 - c. Fabricated from non-ferrous components or ferrous components with corrosion-resistant finish.
 - d. Wheels statically and dynamically balanced.
 - 2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
 - 3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 - 4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
 - 5. Vibration Control: Integral isolation to dampen vibration transmission.
- F. Filter Assembly:
 - 1. Access: Bottom, side, or rear to accommodate field installation without removing ductwork and to accommodate filter replacement without need for tools.
 - 2. Efficiency: ASHRAE 52.2, MERV 7.
 - 3. "Media" Subparagraph below describes two filter types: "replaceable" and "washable." Replaceable filters allow for higher filter efficiency. Washable filters have lower filter

efficiency. Requirements may not be available on some products from some manufacturers. Consult manufacturers for availability.

4. Media: If more than one filter type is indicated, Contractor has option to choose.
 - a. Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
 - b. Washable: Manufacturer's standard filter with antimicrobial treatment.

G. Unit Controls:

1. Enclosure: Metal, suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Features and Functions:
 - a. Self-diagnostics.
 - b. Time delay.
 - c. Auto-restart.
 - d. External static pressure control.
 - e. Auto operation mode.
 - f. Manual operation mode.
 - g. Filter service notification.
 - h. Power consumption display.
 - i. Drain assembly high water level safety shutdown and notification.
 - j. Run test switch.
4. Communication: Network communication with other indoor and outdoor units.
5. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

H. Unit Electrical:

1. Enclosure: Metal, suitable for indoor locations.
2. Field Connection: Single point connection to power unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways.

2.5 INDOOR, RECESSED, CEILING-MOUNTED UNITS

- A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.

B. Cabinet:

1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1,]to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.

3. Coil Tubes: Copper, of diameter and thickness required by performance.
 4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
 5. Internal Tubing: Copper tubing with brazed joints.
 6. Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 7. Field Piping Connections: Manufacturer's standard.
 8. Factory Charge: Dehydrated air or nitrogen.
 9. Testing: Factory pressure tested and verified to be without leaks.
- D. Drain Assembly:
1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
 2. Condensate Removal: Unit-mounted pump or other integral lifting mechanism, capable of lifting drain water to an elevation above top of cabinet.
 3. Field Piping Connection: Non-ferrous material with threaded NPT.
- E. Fan and Motor Assembly:
1. Fan(s):
 - a. Direct-drive arrangement.
 - b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
 - c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
 - d. Wheels statically and dynamically balanced.
 2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
 3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
 5. Vibration Control: Integral isolation to dampen vibration transmission.
- F. Filter Assembly:
1. Access: Bottom, to accommodate filter replacement without the need for tools.
 2. Efficiency: ASHRAE 52.2, MERV 7.
 3. Media: If more than one filter type is indicated, Contractor has option to choose.
 - a. Replaceable: Extended surface, panel, or cartridge with antimicrobial treatment fiber media.
 - b. Washable: Manufacturer's standard filter with antimicrobial treatment.
- G. Discharge-Air Grille Assembly: Mounted in bottom of unit cabinet.
1. Discharge Pattern: One-, two-, three-, or four-way throw as indicated on Drawings.
 - a. Discharge Pattern Adjustment: Field-adjustable limits for up and down range of motion.
 - b. Discharge Pattern Closure: Ability to close individual discharges of units with multiple patterns.
 2. Motorized Vanes: Modulating up and down flow pattern for uniform room air distribution.
 3. Additional Branch Supply Duct Connection: Sheet metal knockout for optional connection to one additional supply branch duct.
- H. Return-Air Grille Assembly: Manufacturer's standard grille mounted in bottom of unit cabinet.
- I. Outdoor Air Ventilation Connection: Sheet metal knockout for optional connection to outdoor air ventilation duct.
- J. Unit Controls:
1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
 2. Factory-Installed Controller: Configurable digital control.

3. "Factory-Installed Sensors" Subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.
4. "Features and Functions" Subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.
5. Features and Functions: Self-diagnostics, time delay, auto-restart
6. Communication: Network communication with other indoor units and outdoor unit(s).
7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

K. Unit Electrical:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

2.6 OUTDOOR, AIR-SOURCE HEAT RECOVERY UNITS

- A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
1. Specially designed for use in systems with simultaneous heating and cooling.
 2. Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
 3. All units installed shall be from the same product development generation.
- B. Cabinet:
1. Galvanized steel and coated with a corrosion-resistant finish.
 - a. Coating with documented salt spray test performance of 1000 hours according to ASTM B117 surface scratch test (SST) procedure.
 2. Mounting: Manufacturer-designed provisions for field installation.
 3. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- C. Compressor and Motor Assembly:
1. One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to 15 percent of rated capacity.
 2. Protection: Integral protection against the following:
 - a. High refrigerant pressure.
 - b. Low oil level.
 - c. High oil temperature.
 - d. Thermal and overload.
 - e. Voltage fluctuations.
 - f. Phase failure and phase reversal.
 - g. Short cycling.
 3. Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.

4. Vibration Control: Integral isolation to dampen vibration transmission.
 5. Oil management system to ensure safe and proper lubrication over entire operating range.
 6. Crankcase heaters with integral control to maintain safe operating temperature.
 7. Fusible plug.
- D. Condenser Coil Assembly:
1. Plate Fin Coils:
 - a. Casing: Aluminum, galvanized, or stainless steel.
 - b. Fins: Aluminum or copper, mechanically bonded to tubes, with arrangement required by performance.
 - c. Tubes: Copper, of diameter and thickness required by performance.
 2. Coating: Corrosion resistant.
 3. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
- E. Condenser Fan and Motor Assembly:
1. Fan(s): Propeller type.
 - a. Direct-drive arrangement.
 - b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.
 - c. Statically and dynamically balanced.
 2. Fan Guards: Removable safety guards complying with OSHA regulations. If using metal materials, coat with corrosion-resistant coating to match performance indicated for condenser coil.
 3. Motor(s): Brushless dc or electronically commutated with permanently lubricated bearings and rated for outdoor duty.
 4. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 5. Speed Settings and Control: Variable speed with a speed range of least 75 percent.
 6. Vibration Control: Integral isolation to dampen vibration transmission.
- F. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.
- G. Unit Controls:
1. Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
 2. Factory-Installed Controller: Configurable digital control.
 3. Factory-Installed Sensors:
 - a. Refrigerant suction temperature.
 - b. Refrigerant discharge temperature.
 - c. Outdoor air temperature.
 - d. Refrigerant high pressure.
 - e. Refrigerant low pressure.
 - f. Oil level.
- H. Unit Electrical:
1. Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
 2. Field Connection: Single point connection to power entire unit and integral controls.
 3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
 4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
 5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

- I. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevent corrosion when exposed to salt spray test for [1000] <Insert number> hours according to ASTM B117.
- J. Unit Piping:
 - 1. Unit Tubing: Copper tubing with brazed joints.
 - 2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 - 3. Field Piping Connections: Manufacturer's standard.
 - 4. Factory Charge: Dehydrated air or nitrogen.
 - 5. Testing: Factory pressure tested and verified to be without leaks.

2.7 HEAT RECOVERY CONTROL UNITS (HRCUs)

- A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
 - 1. Specially designed for use in systems with simultaneous heating and cooling.
 - 2. Systems shall consist of one unit, or multiple unit that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
- B. Cabinet:
 - 1. Galvanized-steel construction.
 - 2. Insulation: Manufacturer's standard internal insulation to provide thermal resistance and prevent condensation.
 - 3. Mounting: Manufacturer-designed provisions for field installation.
 - 4. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- C. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.
- D. Refrigeration Assemblies and Specialties:
 - 1. Specially designed by manufacturer for type of VRF HVAC system being installed, either two or three-pipe.
 - 2. Each refrigerant branch circuit shall have refrigerant control valve(s) to control refrigerant flow.
 - 3. Each system piping connection upstream of heat recovery unit shall be fitted with an isolation valve to allow for service to any heat recovery control unit in the system without interrupting operation of the system.
 - 4. Each branch circuit connection shall be fitted with an isolation valve and capped service port to allow for service to any individual branch circuit without interrupting operation of the system.
 - a. If not available as an integral part of the heat recovery control unit, isolation valves shall be field installed adjacent to the unit pipe connection.
- E. Unit Controls:
 - 1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
 - 2. Factory-Installed Controller: Configurable digital control.
 - 3. Features and Functions: Self-diagnostics, fuse protection.
 - 4. Communication: Network communication with indoor units and outdoor unit(s).
 - 5. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 6. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

- F. Unit Electrical:
 - 1. Enclosure: Metal, similar to enclosure, and suitable for indoor locations.
 - 2. Field Connection: Single point connection to power entire unit and integral controls.
 - 3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
 - 4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
 - 5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.
- G. Unit Piping:
 - 1. Unit Tubing: Copper tubing with brazed joints.
 - 2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
 - 3. Field Piping Connections: Manufacturer's standard.
 - 4. Factory Charge: Dehydrated air or nitrogen.
 - 5. Testing: Factory pressure tested and verified to be without leaks.

2.8 SYSTEM CONTROLS

- A. General Requirements:
 - 1. Network: Indoor units, HRCUs, and outdoor units shall include integral controls and connect through a manufacturer-selected control network.
 - 2. Network Communication Protocol: Manufacturer proprietary control communication between interconnected units.
 - 3. Integration with Building Automation System: ASHRAE 135, BACnet IP and certified by BACnet Testing Lab (BTL), including the following:
 - a. Ethernet connection via RJ-45 connectors and port with transmission at 100 Mbps or higher.
 - b. Integration shall include control, monitoring, scheduling and change of value notifications
 - 4. Operator Interface:
 - a. Operators shall interface with system and unit controls through the following:
 - 1) Operator interfaces integral to controllers.
 - 2) Web interface through web browser software.
 - 3) Integration with Building Automation System.
 - b. Users shall be capable of interface with controllers for indoor units control to extent privileges are enabled. Control features available to users shall include the following:
 - 1) Temperature set-point adjustment.
- B. VRF HVAC System Operator Software for PC:
 - 1. Software offered by VRF HVAC system manufacturer shall provide system operators with ability to monitor and control VRF HVAC system(s) from a single dedicated Owner-furnished PC.
 - 2. Software shall provide operator with a graphic user interface to allow monitoring and control of multiple central controllers from a single device location through point-and-click mouse exchange.
 - 3. Plan views shall show building plans with location of indoor units and identification superimposed on plans.
 - 4. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.

5. Schedules operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Schedules daily, weekly, and annual events.
6. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
7. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
8. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
9. Supports Multiple Languages: English
10. Supports Imperial and Metric Temperature Units: Fahrenheit.
11. Displays service notifications and error codes.
12. Monitors and displays error history and operation history for regular reporting and further archiving.
13. Monitors and displays cumulative operating time of indoor units.
14. Able to disable and enable operation of individual controllers for indoor units.
15. Information displayed on individual controllers shall also be available for display.
16. Information displayed for outdoor units, including refrigerant high and low pressures percent capacity

2.9 AIR HANDLING UNIT (AHU) CONTROL KIT

- A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls interfaces required for connecting third-party air handlers with VRF condensing units.
- B. Provide with dry contacts and temperature sensor control of DX coil.

2.10 SYSTEM REFRIGERANT AND OIL

- A. Refrigerant:
 1. As required by VRF HVAC system manufacturer for system to comply with performance requirements indicated.
 2. ASHRAE 34, Class A1 refrigerant classification.
 3. R-410a
- B. Oil:
 1. As required by VRF HVAC system manufacturer and to comply with performance requirements indicated.

2.11 SYSTEM REFRIGERANT PIPING

- A. Comply with requirements in Section 232300 "Refrigerant Piping" for system piping requirements.
- B. Refrigerant Isolation Ball Valves:
 1. Description: Uni-body full port design, rated for maximum system temperature and pressure, and factory tested under pressure to ensure tight shutoff. Designed for valve operation without removing seal cap.
 2. Seals: Compatible with system refrigerant and oil. Seal service life of at least 20 years.
 3. Valve Connections: Flare or sweat depending on size.

2.12 SYSTEM CONDENSATE DRAIN PIPING

- A. Copper Tubing:
 1. Drawn-Temper Tubing: According to ASTM B88, Type L.
 2. Wrought-Copper Fittings: ASME B16.22.

3. Wrought-Copper Unions: ASME B16.22.
4. Solder Filler Metals: ASTM B32, lead-free alloys, and water-flushable flux according to ASTM B813.

2.13 METAL HANGERS AND SUPPORTS

- A. Copper Tube Hangers:
 1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
 2. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized or copper-coated steel or stainless steel.
- B. Plastic Pipe Hangers:
 1. Description: MSS SP-58, Types 1 through 58, galvanized-steel, factory-fabricated components.
 2. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel or stainless steel

2.14 METAL FRAMING SYSTEMS

- A. MFMA Manufacturer Metal Framing Systems:
 1. Description: Shop- or field-fabricated, pipe-support assembly for supporting multiple parallel pipes.
 2. Standard: MFMA-4.
 3. Channels: Continuous slotted steel channel with inturred lips.
 4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel for use indoors and of stainless steel for use outdoors.
 6. Metallic Coating for Use Indoors: Electroplated zinc, hot dip galvanized, or mill galvanized.
 7. Plastic Coating for Use Outdoors: PVC, polyurethane, epoxy, or polyester.

2.15 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded, zinc-coated steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 1. Indoor Applications: Zinc-coated or stainless steel.
 2. Outdoor Applications: Stainless steel.

2.16 PIPE STANDS

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

- C. Low-Type, Single-Pipe Stand: One-piece plastic or stainless-steel base unit with plastic roller, for roof installation without membrane penetration.
- D. High-Type, Single-Pipe Stand:
 - 1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 - 2. Base: Plastic or Stainless steel
 - 3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 - 4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
- E. High-Type, Multiple-Pipe Stand:
 - 1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
 - 2. Bases: One or more; plastic.
 - 3. Vertical Members: Two or more protective-coated-steel channels.
 - 4. Horizontal Member: Protective-coated-steel channel.
 - 5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.
- F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.17 MISCELLANEOUS SUPPORT MATERIALS

- A. Grout: ASTM C1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.
- B. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; galvanized.
- C. Threaded Rods: Continuously threaded. Zinc-plated steel or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar material as rods.

2.18 PIPING AND TUBING INSULATION

- A. Comply with requirements in Section 230719 "HVAC Piping Insulation" for system piping requirements.

2.19 SYSTEM CONTROL CABLE

- A. Cable Rating: Listed and labeled for application according to NFPA 70.
 - 1. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.
 - a. Flame Travel Distance: 60 inches or less.
 - b. Peak Optical Smoke Density: 0.5 or less.
 - c. Average Optical Smoke Density: 0.15 or less.
 - 2. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.
 - 3. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

- B. Low-Voltage Control Cabling:
1. Paired Cable: NFPA 70, Type CMG.
 - a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
 - b. PVC insulation.
 - c. Braided or foil shielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with UL 1685.
 2. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
 - a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
 - b. PVC insulation.
 - c. Braided or foil shielded.
 - d. PVC jacket.
 - e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
 - f. Flame Resistance: Comply with NFPA 262.
- C. TIA-485A Network Cabling:
1. Standard Cable: NFPA 70, Type CMG.
 - a. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - b. PVC insulation.
 - c. Unshielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with UL 1685.
 2. Plenum-Rated Cable: NFPA 70, Type CMP.
 - a. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - b. Fluorinated ethylene propylene insulation.
 - c. Unshielded.
 - d. Fluorinated ethylene propylene jacket.
 - e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
 - f. Flame Resistance: NFPA 262.
- D. Ethernet Network Cabling: TIA-568-C.2 Category 6a cable with RJ-45 connectors.
1. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of category cable indicated.
 2. Conductors: 100-ohm, 23 AWG solid copper.
 3. Shielding: Unshielded twisted pairs (UTP).
 4. Cable Rating: By application.
 5. Jacket: White thermoplastic.
- E. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for control wiring and cable raceways.

2.20 MATERIALS

- A. Steel:
1. ASTM A36/A36M for carbon structural steel.
 2. ASTM A568/A568M for steel sheet.
- B. Stainless Steel:
1. Manufacturer's standard grade for casing.

2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A653/A653M.

D. Aluminum: ASTM B209.

2.21 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect factory-assembled equipment.
- B. Equipment will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports for historical record. Submit reports only if requested.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine products before installation. Reject products that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for piping and tubing to verify actual locations of connections before equipment installation.
- D. Examine roughing-in for ductwork to verify actual locations of connections before equipment installation.
- E. Examine roughing-in for wiring and conduit to verify actual locations of connections before equipment installation.
- F. Examine walls, floors, roofs, and outdoor pads for suitable conditions where equipment will be installed.
- G. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- H. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION, GENERAL

- A. Clearance:
 1. Maintain manufacturer's recommended clearances for service and maintenance.
 2. Maintain clearances required by governing code.
- B. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory mounted.
 1. Loose components shall be installed by manufacturer's service representative with the exception of any field installed condensate pumps or FCU controllers which shall be installed by the Division 23 contractor.

3.3 INSTALLATION OF INDOOR UNITS

- A. Install units to be level and plumb while providing a neat and finished appearance.
- B. Unless otherwise required by VRF HVAC system manufacturer, support ceiling-mounted units from structure above using threaded rods; minimum rod size of 3/8 inch.
- C. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.
- D. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replaced damaged areas after units are installed.
- E. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.
- F. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.
- G. Provide lateral bracing if needed to limit movement of suspended units to not more than 0.25 inch.
- H. Attachment: Install hardware for proper attachment to supported equipment.

3.4 INSTALLATION OF OUTDOOR UNITS

- A. Install units to be level and plumb while providing a neat and finished appearance.
- B. Install outdoor units on support structures indicated on Drawings.

3.5 GENERAL REQUIREMENTS FOR PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping and tubing systems. Install piping and tubing as indicated unless deviations to layout are approved on coordination drawings.
- B. Install piping and tubing in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping and tubing at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping and tubing above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping and tubing to permit valve servicing.
- F. Install piping and tubing at indicated slopes.
- G. Install piping and tubing free of sags.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping and tubing to allow application of insulation.

- J. Install groups of pipes and tubing parallel to each other, spaced to permit applying insulation with service access between insulated piping and tubing.
- K. Install sleeves for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- L. Install escutcheons for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.6 INSTALLATION OF SYSTEM CONDENSATE DRAIN PIPING

- A. General Requirements for Drain Piping and Tubing:
 - 1. Install a union in piping at each threaded unit connection.
 - 2. Install an adjustable stainless-steel hose clamp with adjustable gear operator on unit hose connections. Tighten clamp to provide a leak-free installation.
 - 3. If required for unit installation, provide a trap assembly in drain piping to prevent air circulated through unit from passing through drain piping. Comply with more stringent of the following:
 - a. Details indicated on Drawings.
 - b. Manufacturer's requirements.
 - c. Governing codes.
 - d. In the absence of requirements, comply with requirements of ASHRAE handbooks.
 - 4. Extend drain piping from units with drain connections to drain receptors as indicated on Drawings. If not indicated on Drawings, terminate drain connection at nearest accessible location that is not exposed to view by occupants.
 - 5. Provide each 90-degree change in direction with a Y- or T-fitting. Install a threaded plug connection in the dormant side of fitting or future use as a service cleanout.
- B. Gravity Drains:
 - 1. Slope piping from unit connection toward drain termination at a constant slope of not less than one percent.
- C. Pumped Drains:
 - 1. If unit condensate pump or lift mechanism is not included with an integral check valve, install a full-size check valve in each branch pipe near unit connection to prevent backflow into unit.

3.7 INSTALLATION OF REFRIGERANT PIPING

- A. Refrigerant Tubing Kits:
 - 1. Unroll and straighten tubing to suit installation. Deviations in straightness of exposed tubing shall be unnoticeable to observer.
 - 2. Support tubing using hangers and supports indicated at intervals not to exceed 5 feet. Minimum rod size, 1/4 inch.
 - 3. Prepare tubing ends and make mating connections to provide a pressure tight and leak-free installation.
- B. Install refrigerant piping according to ASHRAE 15 and governing codes.
- C. Select system components with pressure rating equal to or greater than system operating pressure.
- D. Install piping as short and direct as possible, with a minimum number of joints and fittings.

- E. Arrange piping to allow inspection and service of equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- F. Install refrigerant piping and tubing in protective conduit where installed belowground.
- G. Install refrigerant piping and tubing in rigid or flexible conduit in locations where exposed to mechanical damage.
- H. Unless otherwise required by VRF HVAC system manufacturer, slope refrigerant piping and tubing as follows:
 - 1. Install horizontal hot-gas discharge piping and tubing with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Install traps to entrain oil in vertical runs.
 - 4. Liquid lines may be installed level.
- I. When brazing, remove or protect components that could be damaged by heat.
- J. Before installation, clean piping, tubing, and fittings to cleanliness level required by VRF HVAC system manufacturer.
- K. Joint Construction:
 - 1. Ream ends of tubes and remove burrs.
 - 2. Remove scale, slag, dirt, and debris from inside and outside of tube and fittings before assembly.
 - 3. Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
 - a. Use Type BCuP (copper-phosphorus) alloy for joining copper fittings with copper tubing.
 - b. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze.

3.8 INSTALLATION OF METAL HANGERS AND SUPPORTS

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- C. Comply with MFMA-103 for metal framing system selections and applications that are not specified.
- D. Fastener System Installation:
 - 1. Install powder-actuated fasteners, for use in lightweight concrete or concrete slabs less than 4 inches thick, in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- E. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.
- F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- G. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- H. Install lateral bracing with pipe hangers and supports to prevent swaying.
- I. Install building attachments within concrete slabs or attach to structural steel.
1. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- J. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- K. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- L. Piping and Tubing Insulation:
1. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 2. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
- M. Horizontal-Piping Hangers and Supports: Install the following types:
1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.
 2. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
 3. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 4. Multiple horizontal pipes located indoors may use metal framing systems with split clamp attachment for each pipe in lieu of individual clevis hangers.
 5. Pipe stands for horizontal pipes located outdoors.
 6. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
 7. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.
- N. Horizontal Piping Hanger Spacing and Rod Size: Install hangers for drawn-temper copper piping with the following maximum horizontal spacing and minimum rod sizes:
1. Sizes through NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
 2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
 3. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
 4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
 7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

- O. Vertical-Piping Clamps: Install the following types:
 - 1. Extension Pipe or Riser Clamps (MSS Type 8).
 - 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): If longer ends are required for riser clamps.
- P. Support vertical runs at roof, at each floor, and at midpoint intervals between floors, not to exceed 10 feet
- Q. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified.
- R. Use hangers, supports, and attachments with galvanized coatings unless otherwise indicated.
- S. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- T. Trim excess length of continuous-thread hanger and support rods to 1 inch Hanger-Rod Attachments: Install the following types:
 - 1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 - 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 - 3. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 - 4. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- U. Building Attachments: Install the following types:
 - 1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 - 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction, to attach to top flange of structural shape.
 - 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 - 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 - 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 - 6. C-Clamps (MSS Type 23): For structural shapes.
 - 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 - 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 - 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 - 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 - 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 - 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 - 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 - 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

3.9 INSTALLATION OF PIPING AND TUBING INSULATION

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated. Installation to maintain a continuous vapor barrier.
- B. Insulation Installation on Pipe Fittings and Elbows:
 - 1. Install mitered sections of pipe insulation.
 - 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Valves and Pipe Specialties:
 - 1. Install preformed valve covers manufactured of same material as pipe insulation when available.
 - 2. When preformed valve covers are unavailable, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - 3. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints, for horizontal applications. Seal with manufacturer's recommended adhesive.
 - 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- E. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.10 INSTALLATION OF DUCT, ACCESSORIES, AND AIR OUTLETS

- A. Where installing ductwork adjacent to equipment, allow space for service and maintenance.
- B. Comply with requirements for metal ducts specified in Section 233113 "Metal Ducts."
- C. Comply with requirements for air duct accessories specified in Section 233300 "Air Duct Accessories."
- D. Comply with requirements for flexible ducts specified in Section 233346 "Flexible Ducts."
- E. Comply with requirements for air diffusers specified in Section 233713.13 "Air Diffusers."
- F. Comply with requirements for registers and grilles specified in Section 233713.23 "Registers and Grilles."

3.11 ELECTRICAL INSTALLATION

- A. Comply with requirements indicated on Drawings and in applicable Division 26 Sections.
- B. To extent electrical power is required for system equipment, components, and controls, and is not indicated on Drawings and addressed in the Specifications, the design for such electrical power shall be delegated to VRF HVAC system provider.

1. Delegated design of electrical power to equipment, components and controls, and associated installation shall be included at no additional cost to Owner.
- C. Connect field electrical power source to each separate electrical device requiring field electrical power. Coordinate termination point and connection type with Installer.
- D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.
- E. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.
- F. Install nameplate or acrylic label with self-adhesive back for each electrical connection indicating electrical equipment designation and circuit number feeding connection.
 1. Nameplate shall be laminated phenolic layers of black with engraved white letters. Letters at least 1/2 inch high.
 2. Locate nameplate or label where easily visible.
- G. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or revised in this Section.
 1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.
 2. Flexible metal conduit shall not be used.
- H. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.
- I. Install manufactured conduit sweeps and long-radius elbows if possible.
- J. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.12 SOFTWARE

- A. Cybersecurity:
 1. Software:
 - a. Coordinate security requirements with owner and/or owner's representative.
 - b. Ensure that latest stable software release is installed and properly operating.
 - c. Disable or change default passwords to password using a combination of uppercase and lower letters, numbers, and symbols at least eight characters in length. Record passwords and turn over to party responsible for system operation and administration.
 2. Hardware:
 - a. Coordinate location and access requirements with owner and/or owner's representative.
 - b. Enable highest level of wireless encryption that is compatible with Owner's ICT network.
 - c. Disable dual network connections.

3.13 INSTALLATION OF SYSTEM CONTROL CABLE

- A. Comply with NECA 1.

- B. Installation Method:
1. Install cables in raceways except as follows:
 - a. Within equipment and associated control enclosures.
 - b. In gypsum board partitions where cable may be enclosed within wall cavity.
 2. Conceal raceway and cables except in unfinished spaces.
- C. General Requirements for Cabling:
1. Comply with TIA-568-C Series of standards.
 2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."
 3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
 4. Cables may not be spliced and shall be continuous from terminal to terminal. Do not splice cable.
 5. Cables serving a common system may be grouped in a common raceway. Install control cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
 6. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.
 8. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
 9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
 10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.
 11. Support: Do not allow cables to lie on removable ceiling tiles or access panels.
 12. Secure: Fasten securely in place with hardware specifically designed and installed so as to not damage cables.
 13. Provide strain relief.
 14. Keep runs short. Allow extra length for connecting to terminals.
 15. Do not bend cables in a radius less than 10 times the cable OD.
 16. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
 17. Ground wire shall be copper, and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.
- D. Balanced Twisted-Pair Cable Installation:
1. Comply with TIA-568-C.2.
 2. Do not untwist balanced twisted-pair cables more than 1/2 inch at the point of termination to maintain cable geometry.
- E. Open-Cable Installation:
1. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 30 inches apart.
 2. Cable shall not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.
- F. Separation from EMI Sources: Comply with BICSI TDMM and TIA-569-D recommendations for separating unshielded cable from potential EMI sources including electrical power wiring and equipment.

3.14 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.15 GROUNDING INSTALLATION

- A. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.
- B. For low-voltage control cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.16 IDENTIFICATION

- A. Identify system equipment, piping, tubing, and valves. Comply with requirements for identification specified in Section 230553 "Identification for HVAC Piping and Equipment."
- B. Identify system electrical and controls components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 - 1. Identify each control cable on each end and at each terminal with a number-coded identification tag. Each cable shall have a unique tag.

3.17 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage VRF HVAC system manufacturer's service representative to advise and assist installers; witness testing; and observe and inspect components, assemblies, and equipment installations, including controls and connections.
 - 1. Field service shall be performed by a factory-trained and -authorized service representative of VRF HVAC system manufacturer whose primary job responsibilities are to provide direct technical support of its products.
 - 2. Manufacturer shall provide on-site visits during the course of construction at installation milestones indicated. System Installer shall coordinate each visit in advance to give manufacturer sufficient notice to plan the visit.
 - a. First Visit: Kick-off meeting.
 - b. Second Visit: At approximately 25 percent completion of system(s).
 - c. Third Visit: At approximately 50 percent completion of system(s).
 - d. Fourth Visit: At approximately 75 percent completion of system(s).
 - e. Fifth Visit: Final inspection before system startup.
 - 3. Kick-off Meeting:
 - a. Meeting shall include system Installer and other related trades with sole purpose of reviewing VRF HVAC system installation requirements and close coordination required to make a successful installation.
 - b. Meeting shall be held at Project site and scheduled at a mutually agreed to time that occurs before the start of any part of system installation.
 - c. Meeting shall cover the following as a minimum requirement:
 - 1) Review of latest issue of Contract Documents, Drawings, and Specifications, relevant to VRF HVAC systems.
 - 2) Manufacturer's installation requirements specific to systems being installed.
 - 3) Review of all relevant VRF HVAC system submittals, including delegated-design submittals.
 - 4) Required field activities related installation of VRF HVAC system.

- 5) Project team communication protocol, contact information, and exchange of responsibilities for each party involved, including manufacturer, supplier, system Installer, and other related trades.
4. Site Visits: Activities for each site visit shall include the following:
 - a. Meet with VRF HVAC system Installer to discuss field activities, issues, and suggested methods to result in a successful installation.
 - b. Offer technical support to Installer and related trades as related to VRF system(s) being installed.
 - c. Review progress of VRF HVAC system(s) installation for strict compliance with manufacturer's requirements.
 - d. Advise and if necessary, assist Installer with updating related refrigerant calculations and system documentation.
 - e. Issue a report for each visit, documenting the visit.
 - 1) Report to include name and contact information of individual making the visit.
 - 2) Date(s) and time frames while on-site.
 - 3) Names and contact information of people meeting with while on-site.
 - 4) Clearly identify and list each separate issue that requires resolution. For each issue, provide a unique identification number, relevant importance, specific location or equipment identification, description of issue, recommended corrective action, and follow-up requirements needed. Include a digital photo for clarification if deemed to be beneficial.
5. Final Inspection before Startup:
 - a. Before inspection, Installer to provide written request to manufacturer stating the system is fully installed according to manufacturer's requirements and ready for final inspection.
 - b. All system equipment and operating components shall be inspected. If components are inaccessible for inspection, they shall be made accessible before the final inspection can be completed.
 - c. Manufacturer shall provide a comprehensive inspection of all equipment and each operating component that comprise the complete system(s). Inspection shall follow a detailed checklist specific to each equipment and operating component.
 - d. Inspection reports for indoor units shall include, but not be limited to, the following:
 - 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low-voltage reading(s) within an acceptable range.
 - 12) Controller type and model controlling unit.
 - 13) Controller location.
 - 14) Temperature settings and readings within an acceptable range.
 - 15) Humidity settings and readings within an acceptable range.
 - 16) Condensate removal acceptable.
 - 17) Fan settings and readings within an acceptable range.
 - 18) Unit airflow direction within an acceptable range.
 - 19) If applicable, fan external static pressure setting.
 - 20) Filter type and condition acceptable.
 - 21) Noise level within an acceptable range.
 - 22) Refrigerant piping properly connected and insulated.

- 23) Condensate drain piping properly connected and insulated.
 - 24) If applicable, ductwork properly connected.
 - 25) If applicable, external interlocks properly connected.
 - 26) Remarks.
 - e. Inspection reports for outdoor units shall include, but not be limited to, the following:
 - 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low-voltage reading(s) within an acceptable range.
 - 12) Condensate removal acceptable.
 - 13) Noise level within an acceptable range.
 - 14) Refrigerant piping properly connected and insulated.
 - 15) Condensate drain piping properly connected and insulated.
 - 16) Remarks.
 - f. Installer shall provide manufacturer with the requested documentation and technical support during inspection.
 - g. Installer shall correct observed deficiencies found by the inspection.
 - h. Upon completing the on-site inspection, manufacturer shall provide a written report with complete documentation describing each inspection step, the result, and any corrective action required.
 - i. If corrective action is required by Installer that cannot be completed during the same visit, provide additional visits, as required, until deficiencies are resolved, and systems are deemed ready for startup.
 - j. Final report shall indicate the system(s) inspected are installed according to manufacturer's requirements and are ready for startup.
- B. Perform the following tests and inspections with the assistance of manufacturer's service representative:
- 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Refrigerant Tubing Positive Pressure Testing:
- 1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
 - 2. After completion of tubing installation, pressurize tubing systems to a test pressure of not less than 1.5 times VRF HVAC system operating pressure, but not less than 600 psig, using dry nitrogen
 - 3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of 24 hours. Allowance for pressure changes attributed to changes in ambient temperature are acceptable.
 - 4. Prepare test report to record the following information for each test:

- a. Name of person starting test, company name, phone number, and e-mail address.
 - b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
 - c. Detailed description of extent of tubing tested.
 - d. Date and time at start of test.
 - e. Test pressure at start of test.
 - f. Outdoor temperature at start of test.
 - g. Name of person ending test, company name, phone number, and e-mail address.
 - h. Date and time at end of test.
 - i. Test pressure at end of test.
 - j. Outdoor temperature at end of test.
 - k. Remarks:
 5. Submit test reports for Project record.
- D. Refrigerant Tubing Evacuation Testing:
1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
 2. After completion of tubing positive-pressure testing, evacuate tubing systems to a pressure of 500 microns.
 3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of one hour(s) with no change.
 4. Prepare test report to record the following information for each test:
 - a. Name of person starting test, company name, phone number, and e-mail address.
 - b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
 - c. Detailed description of extent of tubing tested.
 - d. Date and time at start of test.
 - e. Test pressure at start of test.
 - f. Outdoor temperature at start of test.
 - g. Name of person ending test, company name, phone number, and e-mail address.
 - h. Date and time at end of test.
 - i. Test pressure at end of test.
 - j. Outdoor temperature at end of test.
 - k. Remarks:
 5. Submit test reports for Project record.
 6. Upon successful completion of evacuation testing, system shall be charged with refrigerant.
- E. System Refrigerant Charge:
1. Using information collected from the refrigerant tubing evacuation testing, system Installer shall consult variable refrigerant system manufacturer to determine the correct system refrigerant charge.
 2. Installer shall charge system following VRF HVAC system manufacturer's written instructions.
 3. System refrigerant charging shall be witnessed by system manufacturer's representative.
 4. Total refrigerant charge shall be recorded and permanently displayed at the system's outdoor unit.
- F. Products will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports.

3.18 STARTUP SERVICE

- A. Engage a VRF HVAC system manufacturer's service representative to perform system(s) startup service.
 - 1. Service representative shall be a factory-trained and -authorized service representative of VRF HVAC system manufacturer.
 - 2. Complete startup service of each separate system.
 - 3. Complete system startup service according to manufacturer's written instructions.
- B. Startup checks shall include, but not be limited to, the following:
 - 1. Check control communications of equipment and each operating component in system(s).
 - 2. Check each indoor unit's response to demand for cooling and heating.
 - 3. Check each indoor unit's response to changes in airflow settings.
 - 4. Check each indoor unit, HRCU, and outdoor unit for proper condensate removal.
 - 5. Check sound levels of each indoor and outdoor unit.
- C. Installer shall accompany manufacturer's service representative during startup service and provide manufacturer's service representative with requested documentation and technical support during startup service.
 - 1. Installer shall correct deficiencies found during startup service for reverification.
- D. System Operation Report:
 - 1. After completion of startup service, manufacturer shall issue a report for each separate system.
 - 2. Report shall include complete documentation describing each startup check, the result, and any corrective action required.
 - 3. Manufacturer shall electronically record not less than two hours of continuous operation of each system and submit with report for historical reference.
 - a. All available system operating parameters shall be included in the information submitted.
- E. Witness:
 - 1. Invite Owner and Commissioning Agent to witness startup service procedures.
 - 2. Provide written notice not less than 20 business days before start of startup service.

3.19 ADJUSTING

- A. Adjust equipment and components to function smoothly and lubricate as recommended by manufacturer.
- B. Adjust initial temperature and humidity set points. Adjust initial airflow settings and discharge airflow patterns.
- C. Set field-adjustable switches and circuit-breaker trip ranges according to VRF HVAC system manufacturer's written instructions, and as indicated.
- D. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.20 PROTECTION

- A. Protect products from moisture and water damage. Remove and replace products that are wet, moisture damaged, or mold damaged.
- B. Protect equipment from physical damage. Replace equipment with physical damage that cannot be repaired to new condition. Observable surface imperfections shall be grounds for removal and replacement.
- C. Protect equipment from electrical damage. Replace equipment suffering electrical damage.
- D. Cover and seal openings of equipment to keep inside of equipment clean. Do not remove covers until finish work is complete.

3.21 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by manufacturer's authorized service representative. Include two service visits for preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper equipment and system operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.22 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
 - 1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.23 DEMONSTRATION

- A. Engage a VRF HVAC system manufacturer's factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain entire system.
- B. Instructor:
 - 1. Instructor shall be factory trained and certified by VRF HVAC system manufacturer with current training on the system(s), equipment, and controls that are installed.
 - 2. Instructor's credentials shall be submitted for review by Commissioning Agent and Owner before scheduling training.
 - 3. Instructor(s) primary job responsibility shall be Owner training.
 - 4. Instructor(s) shall have not less than three years of training experience with VRF HVAC system manufacturer and past training experience on at least three projects of comparable size and complexity.
- C. Schedule and Duration:
 - 1. Schedule training with Owner at least 20 business days before first training session.
 - 2. Training shall occur before Owner occupancy.
 - 3. Training shall be held at mutually agreed date and time during normal business hours.

4. Each training day shall not exceed eight hours of training. Daily training schedule shall allow time for one-hour lunch period and 15-minute break after every two hours of training.
 5. Perform not less than eight total hours of training.
- D. Location: Owner shall provide a suitable on-site location to host classroom training.
- E. Training Attendees: Assume three people.
- F. Training Attendance: For record purposes, document training attendees at the start of each new training session. Record attendee's name, signature, phone number, and e-mail address.
- G. Training Format: Individual training modules shall include classroom training followed by hands-on field demonstration and training.
- H. Training Materials: Provide training materials in electronic format to each attendee.
1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
 2. Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.
- I. Acceptance: Obtain Commissioning Agent or Owner written acceptance that training is complete, and requirements indicated have been satisfied.

END OF SECTION

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SECTION 238216.14

ELECTRIC-RESISTANCE AIR COILS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes electric resistance air coils.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
 - 2. Include rated capacities, operating characteristics, and pressure drops for each air coil.
- B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which coil location and ceiling-mounted access panels are shown and coordinated with each other.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

1.6 FIELD CONDITIONS

- A. Altitude above Mean Sea Level: 0

PART 2 - PRODUCTS

2.1 DESCRIPTION

- A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2.2 COILS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Brasch Manufacturing Co., Inc.
 2. Dunham-Bush, Inc.
 3. INDEECO.
 4. Trane.
- B. Testing Agency Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Coil Assembly: Comply with UL 1995.
- D. Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
- E. Heating Elements: Open-coil resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, and fastened to supporting brackets.
- F. High-Temperature Coil Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or casing.
1. Secondary Protection: Load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
- G. Frames: Galvanized-steel channel frame, minimum 0.052 inch thick for slip-in mounting.
- H. Control Panel: Unit mounted with disconnecting means and overcurrent protection. Include the following controls:
1. Magnetic contactor.
 2. Mercury contactor.
 3. Toggle switches; one per step.
 4. Step controller.
 5. Time-delay relay.
 6. Pilot lights; one per step.
 7. Airflow proving switch.
- I. Thermostats: Wall-mounted thermostats, with temperature range from 50 to 90 deg F, and 2.5 deg F throttling range.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install coils level and plumb.

- B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
- C. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.
- D. Install coils in strict accordance with the manufacturer's installation instructions.

3.3 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Operational Test: After electrical circuitry has been energized, operate electric coils to confirm proper unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Prepare test and inspection reports.

END OF SECTION

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SECTION 238239.13

CABINET UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes cabinet unit heaters with centrifugal fans and electric-resistance heating coils.

1.3 DEFINITIONS

- A. CWP: Cold working pressure.
- B. DDC: Direct digital control.
- C. PTFE: Polytetrafluoroethylene plastic.
- D. TFE: Tetrafluoroethylene plastic.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. LEED Submittals:
 - 1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
- C. Shop Drawings:
 - 1. Include plans, elevations, sections, and details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include location and size of each field connection.
 - 4. Include details of anchorages and attachments to structure and to supported equipment.
 - 5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
 - 6. Indicate location and arrangement of piping valves and specialties.
 - 7. Wiring Diagrams: Power, signal, and control wiring.
- D. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.

- E. Samples for Verification: Finish colors for each type of cabinet unit heater indicated with factory-applied color finishes.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Suspended ceiling components.
 - 2. Structural members to which cabinet unit heaters will be attached.
 - 3. Method of attaching hangers to building structure.
 - 4. Size and location of initial access modules for acoustical tile.
 - 5. Items penetrating finished ceiling, including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - 6. Perimeter moldings for exposed or partially exposed cabinets.
- B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For cabinet unit heaters to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Cabinet Unit-Heater Filters: Furnish one spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Berko: Marley Engineered Products.
 - 2. INDEECO.
 - 3. Marley Engineered Products.

2.2 DESCRIPTION

- A. Factory-assembled and -tested unit complying with AHRI 440.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- C. Comply with UL 2021.

2.3 PERFORMANCE REQUIREMENTS

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.4 CABINETS

- A. Material: Steel with baked-enamel finish with manufacturer's custom paint, in color selected by Architect.
 - 1. Vertical Unit, Exposed Front Panels: Minimum 0.0528-inch-thick galvanized sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
 - 2. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0528-inch-thick galvanized sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
 - 3. Recessed Flanges: Steel, finished to match cabinet.
 - 4. Control Access Door: Key operated.

2.5 COILS

- A. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, mounted in ceramic inserts in galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

2.6 CONTROLS

- A. Fan and Motor Board: Removable.
 - 1. Fan: Forward curved, double width, centrifugal, directly connected to motor; thermoplastic or painted-steel wheels and aluminum, painted-steel, or galvanized-steel fan scrolls.
 - 2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - 3. Wiring Terminations: Connect motor to chassis wiring with plug connection.
- B. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- C. Basic Unit Controls:
 - 1. Control voltage transformer.
 - 2. Wall-mounted thermostat with the following features:
 - a. Heat-off switch.
 - b. Fan on-auto switch.
 - c. Manual fan-speed switch.
 - d. Adjustable deadband.

- e. Concealed set point.
 - f. Concealed indication.
 - g. Deg F indication.
- 3. Unoccupied period override push button.
- 4. Data entry and access port.
 - a. Input data includes room temperature and occupied and unoccupied periods.
 - b. Output data includes room temperature, supply-air temperature, entering-water temperature, operating mode, and status.
- D. Interface with DDC System for HVAC Requirements:
 - 1. Interface relay for scheduled operation.
 - 2. Interface relay to provide indication of fault at central workstation.
 - 3. Interface shall be BAC-net compatible for central DDC system for HVAC workstation and include the following functions:
 - a. Adjust set points.
 - b. Cabinet unit-heater start, stop, and operating status.
 - c. Data inquiry, including supply-air and room-air temperature.
 - d. Occupied and unoccupied schedules.
- E. Electrical Connection: Factory-wired motors and controls for a single field connection.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for electrical connections to verify actual locations before unit-heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wall boxes in finished wall assembly, seal and weatherproof. Joint-sealant materials and applications are specified in Section 079200 "Joint Sealants."
- B. Install cabinet unit heaters to comply with NFPA 90A.
- C. Suspend cabinet unit heaters from structure with elastomeric hangers. Vibration isolators are specified in Section 230548.13 "Vibration Controls for HVAC."
- D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.
- E. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

3.3 CONNECTIONS

- A. Comply with safety requirements in UL 1995.
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- B. Units will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Adjust initial temperature set points.
- B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters.

END OF SECTION

SECTION 238239.19

WALL AND CEILING UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes wall and ceiling heaters with propeller fans and electric-resistance heating coils.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. LEED Submittals:
 - 1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
- C. Shop Drawings:
 - 1. Include plans, elevations, sections, and details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include details of anchorages and attachments to structure and to supported equipment.
 - 4. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
 - 5. Wiring Diagrams: Power, signal, and control wiring.
- D. Samples: For each exposed product and for each color and texture specified.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wall and ceiling unit heaters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Berko; Marley Engineered Products.
2. INDEECO.
3. Marley Engineered Products.
4. QMark; Marley Engineered Products.

2.2 DESCRIPTION

- A. Assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 CABINET

- A. Front Panel: Extruded-aluminum bar grille, with removable panels fastened with tamperproof fasteners.
- B. Finish: Baked enamel over baked-on primer with manufacturer's standard color selected by Architect, applied to factory-assembled and -tested wall and ceiling heaters before shipping.
- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Surface-Mounted Cabinet Enclosure: Steel with finish to match cabinet.

2.4 COIL

- A. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high-temperature protection. Provide integral circuit breaker for overcurrent protection.

2.5 FAN AND MOTOR

- A. Fan: Aluminum propeller directly connected to motor.
- B. Motor: Permanently lubricated, multispeed. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.6 CONTROLS

- A. Controls: Low-voltage relay with transformer kit.
- B. Electrical Connection: Factory wire motors and controls for a single field connection with disconnect switch.
- C. Wall mounted thermostat as specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive wall and ceiling unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for electrical connections to verify actual locations before unit-heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wall and ceiling unit heaters to comply with NFPA 90A.
- B. Install wall and ceiling unit heaters level and plumb.
- C. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.
- D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION

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SECTION 260000

GENERAL REQUIREMENTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 FILING OF TRADE BIDS

- A. Trade Bids shall be submitted in accordance with the provisions of the General Laws (Ter. Ed.), Chapter 149, SECTIONS 44A to 44L, inclusive, as set forth under IN- STRUCTIONS TO BIDDERS.
- B. Each Trade Bid filed with the Awarding Authority must be accompanied by a BID BOND, CASH or CERTIFIED CHECK, or a TREASURER'S CHECK or CASHIER'S CHECK is- sued by a responsible bank or trust company, payable to the City of Boston, the amount stipulated in the INSTRUCTIONS TO BIDDERS. A Trade Bid accompanied by any other form of bid deposit than those specified will be rejected.
- C. Each Trade submitted for the work under the Section, shall be on a form furnished by the Awarding Authority, reference SECTION 44F of Chapter 149 of the General Laws, as amended.
- D. Work to be done under this Section is shown on the following drawings numbered: All E drawings, FA drawings, TC drawings.
- E. The listing of the Contract Drawings above shall not limit responsibility to determine the full extent of work of this Section as required by all Contract Drawings noted on the Contract Drawings-Title Sheet Drawing List, the Project Manual, and Addenda. The remaining Contract Drawings are included for reference and coordination. The Specific additional Scopes of Work required for this Trade Contractor are defined in the Consigli Bid Package #3: Contraction Documents Supplemental Instructions to Bidders, Specification Section 002203
- F. Refer and comply with General Instructions prepared by the CM-R.
- G. Work to be done under this SECTION 260000 shall refer to and include the following specification SECTIONS:

26 00 00	GENERAL REQUIREMENTS ELECTRICAL
26 00 01	METERING
26 00 05	COORDINATION DWG REQ ELECTRICAL
26 05 19	LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES
26 05 26	GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS
26 05 19	HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS
26 05 33	RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS
26 05 44	SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING
26 05 53	IDENTIFICATION FOR ELECTRICAL SYSTEMS
26 05 73.13 SF	SHORT-CIRCUIT STUDIES
26 05 73.16 SF	COORDINATION STUDIES
26 05 73.19 SF	ARC-FLASH HAZARD ANALYSIS
26 09 43.16 SF	DIGITAL AND WIRELESS LIGHTING CONTROLS
26 22 13	LOW-VOLTAGE DISTRIBUTION TRANSFORMERS
26 41 13	SWITCHBOARDS
26 24 16	PANELBOARDS

GENERAL REQUIREMENTS FOR ELECTRICAL

26 27 26	WIRING DEVICES
26 28 16	ENCLOSED SWITCHES AND CIRCUIT BREAKERS
26 36 00	TRANSFER SWITCHES

- H. The filed Trade Bidder for Work under this SECTION 260000 shall list in Paragraph E of the FORM FOR TRADE BIDE the names of each person, fire, or corporation whom he proposes to use to perform the following classes of work or part thereof and the bid price, therefore.

CLASS(ES) OF WORK	REFERENCE ARTICLE(S)
THEATER RIGGING	116133
THEATER LIGHTING FIXTURES	116191
THEATER LIGHTING CONTROLS	265561
COMMUNICATIONS	270000
DISTRIBUTED COMMUNICATION SYSTEM	275000
AUDIOVISUAL SYSTEMS	274100
AUDIOVISUAL SYSTEMS APPENDIX A	274100
NETWORK SWITCH ELECTRONICS	272000
ELECTRONIC SECURITY GENERAL REQUIREMENTS	280000
CONDUCTORS AND CABLES FOR ELECTRONIC SECURITY SYSTEMS	280513
PATHWAYS FOR ELECTRONIC SECURITY SYSTEMS	280518
ACCESS CONTROL SYSTEM	281300
INTRUSION DETECTION SYSTEM	281500
VIDEO SURVEILLANCE SYSTEM	282000
SECURITY COMMUNICATION SYSTEMS	282300
ADDRESSABLE FIRE-ALARM SYSTEMS	264621
LIGHTNING PROTECTION	260000

7. In any case in which the sub-bidder intends to perform with persons of their own staff the class of work listed above, they must nevertheless list their own name therefore under Paragraph E of the FORM FOR SUB-BID.

8. The Electrical Subcontractor and associated Sub-Subcontractors are specifically directed to review the Fire Protection Narrative Report. All design criteria, coordination issues, testing, and other related items, must be incorporated prior to acceptance of the Fire Protection Systems.

1.2 COMMISSIONING

- A. Commissioning: Each contractor and vendor shall be part of a total building and system commissioning effort as conducted by the Commissioning Agent. Each contractor shall provide a technician and tools required to assist and facilitate the commissioning agent, as outlined by the commissioning plan. Full scope of work and all related responsibilities will be defined in Commissioning documentation.

1.3 RELATED DOCUMENTS:

- A. Division 01 Specifications, General and Supplemental Requirements apply to this section with additions and modifications specified herein.
- B. Instructions to Bidders, Bidding Forms, Forms of Agreement between Owner and Contractor, Contract Award Date, Starting and Completion Dates, Conditions of the Contract, Insurance Requirements, and other Owner Requirements will be furnished separately by the Owner, CM. These documents, as well as any addenda issued, shall form a part of these Specifications, and this Contractor shall consult them in detail for instructions pertaining to his work.
- C. Each trade contractor shall receive all drawings and specification sections issued as part of the overall bid package. All contractors are to receive, review, and coordinate all of their work as shown or referenced on the other trade documents. All work shown or referenced on the other trade documents shall be included as part of the overall project scope for that particular discipline and trade.

1.4 SCOPE OF WORK:

- A. These specifications and accompanying drawings are intended to cover the furnishing of all labor, material, and equipment and superintendence of the Electrical System for.
 1. Including Pre-Purchase Switchboard: SECTION 262413 SWITCHBOARDS, & Pre-Purchase 1 MW Generator: SECTION 263213.13 DIESEL-ENGINE-DRIVEN GENERATOR SETS
- B. It is the intent and purpose of these specifications and accompanying drawings to cover and include each item, all materials, machinery, apparatus, and labor necessary to properly install, equip, adjust, and put into perfect operation the respective portions of the installations specified and to so interconnect the various items or sections of the work as to form a complete and properly operating whole.
- C. Any equipment, apparatus, machinery, material, and small items not mentioned in detail, and labor not hereinafter specifically mentioned, which may be found necessary to complete or perfect any portion of installation in a substantial manner, and in compliance with the requirements stated, implied, or intended in these specifications shall be furnished without extra cost. This shall include all materials, devices, or methods peculiar to the machinery, equipment, apparatus, or systems furnished and installed as part of the ELECTRICAL work.
- D. The term "Furnish" shall mean to obtain and supply to the job site. The term "Install" shall generally mean to fix in position and connect for use. Where language indicates that one party or trade is to "install" and another is to "connect", the term "install" shall mean only to fix

in position, and "connect" shall mean to make electrical connections to. The term "Provide" shall mean to furnish and install.

1.5 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Receive, store, transport to site and install pre-purchased Switchboards: SECTION 262413 SWITCHBOARDS
- B. Receive, store, transport to site and install pre-purchased 1 MW Generator: SECTION 263213.13 DIESEL-ENGINE-DRIVEN GENERATOR SETS

1.6 LAWS, REGULATIONS AND CODES:

- A. Perform all work in strict compliance with all laws, regulations, and/or codes applying, including all Federal, State and local codes and any other authority having jurisdiction. Wherever drawings or specifications conflict with such regulations they shall be made to conform, and approval of the Design Professional obtained on such changes as may be involved.
- B. All electrical work shall comply with the requirements of the National Electrical Code, latest revision.

1.7 PERMITS, FEES, AND CERTIFICATES OF APPROVAL:

- A. Unless stated otherwise in General Conditions or Division 1, obtain and pay for all permits, fees, and licenses required, including those of utilities and Agencies. Provide copies to Design Professional in the quantity requested.
 - 1. "Fees" shall include connection charges construction costs, and other such charges by utility companies or service providers. Ascertain such charges during bidding period and include bid price.
- B. As a prerequisite to final acceptance, supply to the Design Professional a Certificate of Inspection from an Electrical Inspection Agency acceptable to the Owner and approved by the local municipality and the utility company serving the project. Certificate shall cover rough wiring, fixtures, and equipment.

1.8 RECORD DRAWINGS:

- A. During construction keep an accurate record of all deviations of the work as shown on the drawings and that which is actually installed.
- B. Secure from the Design Professional, a complete set of prints of the Electrical drawings and note changes thereon. Make a complete record in a neat and accurate manner, of all changes and revisions to original design which exist in completed work and submit CAD file format.
- C. The cost of furnishing above CAD files and preparing these record drawings shall be borne by the Contractor. When all revisions showing the work as finally installed are made, the prints and CAD files shall be submitted for review and approval by the Design Professional.

- D. Record drawings shall be delivered to Owner within 30 days after acceptance of completed project by Owner.

1.9 OPERATING INSTRUCTIONS:

- A. Provide to the Owner three bound copies of complete written instruction on the operation, care and maintenance of each piece of equipment and the installation as a whole. Include frequency of inspection, cleaning and adjusting and other attention as may be required in accordance with manufacturer's instructions. Material shall be manufacturer's brochures, catalog cuts, parts lists, wiring diagrams, etc. Also supply Owner with three complete sets of approved shop drawings.
- B. Furnish qualified personnel to instruct the Owner's personnel in the maintenance and operation of all equipment and systems. Instructing personnel shall remain on the job continuously during working hours until such instruction is complete, but not less than 16 hours.
- C. A video recording in digital format (DVD) of the operator training session shall be made during this training period and the DVD submitted to the Owner with the Operation and Maintenance Manuals.

1.10 CORRECTION OF WORK AFTER FINAL PAYMENT AND GUARANTEE:

- A. This article is supplementary to Guarantee Provisions of Division 1 and General Conditions.
- B. Final payment shall not relieve the Contractor of responsibility for faulty equipment, materials and workmanship and unless otherwise specified he shall remedy any defects due thereto and pay for damage to other work resulting therefrom, which shall appear within a period of one (1) year from the date of acceptance.
- C. Include guarantees by the respective equipment manufacturers which shall be subject to the terms and time limits defined under this Article of Specifications.
- D. Guarantees furnished by Sub-Contractor and/or equipment manufacturers shall be counter-signed by the related Prime Contractor for joint and/or individual responsibility for subject item.
- E. Manufacturers' equipment guarantees or warranties extending beyond the guarantee period described herein shall be transferred to the Owner along with the Contractor's guarantees.

1.11 QUALITY ASSURANCE

- A. Comply with the requirements of the following codes and/or standards:
 - 1. ANSI
 - 2. ASTM
 - 3. UL
 - 4. NEMA
 - 5. NFPA
 - 6. MEC
 - 7. IBC 2009
 - 8. IMC 2009
- B. All packaged equipment shall be independently Third Party labeled as a system for its intended use by a Nationally Recognized Testing Laboratory (NRTL) in accordance with the

OSHA Federal Regulations 29CFR1910.303 and .399, as well as NFPA Pamphlet #70 and National Electric Code (NEC), Article 90-7.

1.12 WARRANTIES:

- A. Manufacturer's warranties on equipment provided under this contract shall be included in the operating and maintenance manuals.
- B. Warrantee period shall begin when the Owner receives beneficial use of the equipment. The installing contractor shall be responsible for protecting all equipment until the testing and balancing reports are accepted and commissioning reports are submitted.
- C. The period of "Owners Beneficial Use" shall begin when:
 - 1. Permanent or temporary certificate of occupancy is granted; or
 - 2. Final Punchlist items are successfully completed; or
 - 3. Owner acknowledges benefits and risks of using the equipment to expedite completion of construction and grants permission for early use of Electrical systems.
- D. See specification section regarding restrictions on early use of Electrical equipment.

1.13 ALTERNATE PRICES:

- A. Refer to Division 01 Sections for list of Alternate Prices being requested for this project, and if they are to be Add or Deduct alternates.
- B. Where Alternate Prices are solicited, the alternate price shall include all work reasonably associated with the work to be priced as an alternate. Base bid conditions shall provide a complete, and fully functional installation, less the work associated with the alternate price.

PART 2 - MATERIALS

2.1 MATERIALS AND EQUIPMENT:

- A. All installed materials and equipment shall be new and the best of their kind and shall conform to the grade, quality and standards specified herein.
- B. Unless otherwise specifically stated, all materials and equipment offered under these specifications shall be limited to products regularly produced and recommended by the manufacturer for the service intended. This material and equipment shall have capacities and ratings sufficient to amply meet the requirements of the project. The capacities and ratings shall be in accord with engineering data or other comprehensive literature made available to the public by the manufacturer and in effect at the time of opening of bids.
- C. Equipment shall be installed in accordance with manufacturer's instructions for type and quality of each piece of equipment used. These instructions shall be obtained from the manufacturer and shall be considered part of these specifications. Type, capacity and application of equipment shall be guaranteed suitable to operate satisfactorily. No experimental material or equipment shall be permitted.

2.2 WORK DESCRIPTION:

- A. In general, the work shall consist of but not necessarily be limited to the following:
1. Install Owner's prepurchased equipment. Refer to Article: ELECTRICAL EQUIPMENT BY OTHERS.
 2. Rough in and make final connections to equipment furnished by Owner or by other Trades. Refer to Article: ELECTRICAL EQUIPMENT BY OTHERS.
 3. Provide new lighting fixtures with lamps, switches, and other controls for areas shown on the Drawings.
 4. Provide receptacles and other outlets, (including surface raceway).
 5. Provide branch circuit wiring from local lighting and power panels for all general light and power circuits.
 6. Provide new emergency lighting fixtures, circuits and distribution equipment as shown on the Drawings.
 7. Provide new branch panels including feeders.
 8. Provide transformers, distribution panels, and other distribution equipment as shown on the Drawings. Include conduit and cable required by Utility Co.
 9. Provide HVAC controls and wiring for same to the extent shown on the drawings or described elsewhere in these Specifications.
 10. Provide all Special Systems described in Specification Sections 260000 and drawing documentation.

2.3 WORK INCLUDED:

- A. In addition to work described above under WORK DESCRIPTION, the work shall include but not necessarily be limited to the following:
1. Provide removals, relocations, alterations and additions to existing electrical equipment and systems as shown on the Drawings. For removals and demolition refer to Article: REMOVAL OF EXISTING EQUIPMENT AND MATERIALS.
 2. Rigging of equipment and materials related to the Electrical Work.
 3. Panel directories for lighting and distribution panels, (including all existing or reconnected circuits). See Section: PANELBOARDS
 4. Lamping of all lighting fixtures.
 5. Grounding and bonding of all systems in accordance with National Electrical Code Requirements.
 6. Providing for electrical inspection of all new electrical work.
 7. Testing and energizing as specified below.
 8. Miscellaneous steel and hangers required for support of electrical equipment.
 9. Furnishing and wiring of smoke detectors for air handling systems shutdown.

2.4 REMOVAL OF EXISTING EQUIPMENT AND MATERIALS:

- A. Remove all superfluous wiring, fixtures, devices, controls, equipment, etc. Where removals are shown on Drawings, they are a general indication only, and may not necessarily indicate the full extent of the work.
- B. No existing equipment or material shall be reused without specific approval of the Owner's Representative.
- C. All equipment and material to be removed, and not desired by the Owner, shall be removed from the site by the Contractor.

- D. Any removed material which is desired by the Owner shall be moved to an on-site storage location by the Contractor.

2.5 CHASES AND OPENINGS:

- A. Provide information to the appropriate trades regarding size and location of all openings and chases as required for the installation of this Electrical Work.

2.6 CUTTING AND PATCHING:

- A. Cutting and chasing for installation of electrical work will be a part of the work of this Contract. Patching and repair of finishes will be by the General Contractor.
- B. Provide sleeves for conduits passing through poured concrete decks, footings, walls, etc. Cut all openings for conduits passing through precast concrete or existing concrete or masonry. Such holes shall be cut with core drill or similar equipment. They shall not be cut with hammer and chisel, or with any power tool depending on impact for its cutting power.

2.7 TESTING AND ENERGIZING:

- A. On completion of the installation and wiring covered by this Specification the installation shall be thoroughly proved free from grounds and short circuits and left ready for operation. Necessary adjustments to all equipment shall be made in cooperation with the manufacturer.
- B. Balance all three-phase panels to within at least ten percent (10%). Submit a report of current readings obtained for each panel after balancing has been completed.
- C. Test all special systems or equipment for proper operation as described in the respective specification sections.
- D. Test all motors for proper rotation. Indicate that rotation by affixing an adhesive arrow equal to Brady Label Co., to the end bell or case of the motor.
- E. Indicate by letter on Company letterhead that all the above testing has been successfully completed.

2.8 ELECTRICAL EQUIPMENT BY OTHERS:

- A. All electrical equipment furnished and installed under contracts other than the Electrical Contract will be furnished with the full complement of control equipment, starters, control wiring conduit and all other items necessary for satisfactory operation.
- B. The Electrical Contractor shall provide disconnect switches for all motor driven equipment with starters not in sight of panelboard, except when combination motor starters are furnished under other contracts or where packaged control panels are mounted on equipment by equipment manufacturer. Refer to schedule on HVAC and Plumbing drawings for such packaged systems provided with combination starters. Refer to the HVAC and Plumbing Specifications for packaged control panels. The Electrical Contractor shall provide disconnect switches at motors when motors are located out of sight of starters or where otherwise required by National Electrical Code. Disconnect switches shall be lockable.
- C. The Electrical Contractor shall mount all starters or unmounted control panels furnished by other trades and shall complete electrical power connections through the disconnect, starter and motor or other device terminals. He shall be responsible for final power connections.

1. Where packaged control panels are furnished by other trades for equipment such as cooling towers, air handling units, or similar items, electrical contractor shall be responsible for all wiring required to connect the motors, contactors, heating elements, sensors, etc., of that equipment to the central panel per wiring diagrams provided by the equipment manufacturer.
 2. It shall be assumed that all wiring instructions provided by equipment manufacturers describe wiring methods, materials, and equipment that complies with the requirements of the National Electrical Code, latest edition. If any such given instruction is found to result in non-NEC compliant conditions, this Contractor shall stop work and request direction from Design Professional.
- D. Single phase motors integral with equipment (heat pumps, unit ventilators, unit heaters, VAV boxes, and similar HVAC equipment; sump pumps, circulators, and similar plumbing equipment) will be furnished with integral or equipment mounted overload heaters by the respective Trade Contractors. The Electrical Contractor shall furnish a motor rated toggle-type disconnect switch for each unit where shown. If the motor or equipment does not have integral overload protection, the HVAC, Plumbing Contractor or equipment supplier will furnish a switch with thermal overload element(s) for installation by the Electrical Contractor.
- E. Where equipment supplied by others is controlled by line-voltage devices (thermostats, speed controllers, timers, etc.), these devices will be furnished for mounting and wiring to the Electrical Contractor by the other trades. See HVAC and plumbing drawings as well as electrical drawing for these devices.
- F. The Electrical Contractor shall complete all power wiring for single phase equipment, through the disconnect and/or the thermal cutouts and local control stations to the equipment as required.
- G. Certain equipment will be furnished and set in place by others. Coordinate work related to co-generation system.
- H. The Electrical Contractor shall provide all rough-ins and make final connections for the various electrical services required for all Owner furnished equipment.
- I. Obtain from Owner, dimensioned equipment drawings, wiring diagrams, and other installation data as may be required to properly complete rough-ins and final connections.

2.9 SUBSTITUTIONS:

- A. Equipment may be shown or specified in several ways:
1. Manufacturer and catalogue or model number with the words "no substitutions," "no equal," "(manufacturer) only," or words of similar respect. Contractor shall furnish the specified item:
 2. Several manufacturers and model numbers listed; or one manufacturer and model number, followed by "equals by (mfr A), (mfr B), (mfr C)," or words of similar respect.
 - a. If one of the manufacturers is listed on the drawings, that manufacturer shall be considered the basis of design. If none is so listed, the first manufacturer named in the Specification shall be considered the basis of design.
 - b. Where manufacturer's or supplier's name, style and catalog numbers are mentioned in the description of material and equipment in the specifications or on the drawings, it is to be understood that they are for the purpose of setting a standard.

- c. If Contractor elects to furnish equipment other than the basis of design, he shall verify capacities, physical size, weight, electrical requirements, methods of connection to other parts of the system, and all other relevant data.
 - d. Contractor shall be responsible for informing the Design Professional of all changes required to other equipment, spaces, structure or systems in order to install the substituted equipment. He shall furnish all required shop drawings or sketches required for Design Professional to evaluate the required changes and shall be responsible for all costs associated with such changes, including costs of design or engineering, if such are necessary, and costs of other trades.
 - 3. Where manufacturer's or supplier's names are listed in conjunction with the manufacturer or supplier that is basis of design, they are given to approve the firm name only. Equipment or material submitted by such firms must meet the detailed technical specifications written for the respective item. Contractor shall be responsible for verifying capacities, physical sizes, weights, electrical requirements, methods of connection to other parts of the system, etc. Contractor shall furnish all required shop drawings for equipment, and for its connection and installation.
 - B. If any substituted items are submitted after contracts have been awarded, and there is any question of equality of such items, samples may be required to be submitted both for the item specified and that to be substituted, or, further proof of equality may be required to the entire satisfaction of the Design Professional. In no case shall additional remuneration be allowed because of the rejection of a substitute.
 - C. When the equipment is relocated to a place other than that shown on the drawings, or when equipment other than that specified is used, the Contractor shall pay the extra cost of required revisions such as structural steel, concrete, electrical, piping, etc.
 - D. The Design Professional's costs to evaluate substitutions and to revise Drawings and Specifications because of substitutions will be paid by the Contractor.
- 2.10 SHOP DRAWINGS:
- A. Refer to Division 1.
 - B. Furnish shop drawings, catalog cuts, performance data and other required data to the Design Professional for approval for all material and equipment specified hereinafter. Sufficient data shall be submitted to show compliance with the requirements of the plans and specifications. All shop drawings submitted shall be first checked and corrected before submitting for approval. Approval for shop drawings by the Design Professional will not relieve the Contractor from responsibility for errors or omissions therein. All such errors or omissions must be made good by the Contractor irrespective of any approval by the Design Professional.
 - C. The following applies to all materials and equipment being submitted for this project. Refer to the individual specification sections for additional submittal requirements.
 - D. It is the responsibility of the manufacturer's representative and the installing contractor to thoroughly review all shop drawing equipment submittals and state in writing that the products meet or exceed the design specifications and design intent as indicated on the contract documents, prior to submitting them for review by the engineer.
 - E. The General Contractor or Construction Manager shall review and stamp all shop drawings noting their review process has taken place and that the shop drawings are in compliance with

the design documents, prior to submitting the for review by the engineer. Any shop drawings found to not be in compliance shall be returned to the contractor stating such, with a copy of the statement (only) forwarded to the engineer.

- F. On submissions beyond the initial one, clearly identify all of the changes made from the initial submittal including those requested by the Design Professional will review only those changes he requested and those identified by the Contractor.
- G. The Engineer will review three submissions (one original submission and up to two revised submissions) on any single component requested for review. If the contractor and/or vendor fail to comply with the drawings, specifications, and/or review comments and additional submissions are required, the cost for review and processing of those submissions will be borne by the contractor.
- H. The design documents are based and coordinated on the scheduled manufacturers. Any substitutions of products or materials (from those approved and listed in the specifications) must be thoroughly coordinated by the submitting contractor. This includes but is not limited to power, space, structural, control and performance requirements.
- I. Shop drawings required shall include, but not necessarily be limited to, the following:
 - 1. Shop drawings, cuts and catalogue information showing appearance, dimensions, performance, weight, etc., of all equipment, fixtures, appurtenances, etc. See section 260100, and respective equipment or system sections for more specific requirements.
 - 2. Schedules of all materials showing type and manufacturer.
 - 3. Wiring diagrams and schematics for equipment.
 - 4. Lighting fixtures, panels, and protective devices, showing appearance, weight, dimensions, finishes, etc.
 - 5. Panels and other protective and distribution equipment.
 - 6. Generator, transfer switches, and system components.
 - 7. All special equipment and systems.
 - 8. Any special constructions.
 - 9. Other shop drawings as may be requested.
- J. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristic, finishes for materials, and installation and startup instructions for each type of product indicated.
 - 1. Each control device labeled with setting or adjustable range of control.
- K. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Schematic flow diagrams showing all controlled equipment and control devices.
 - 2. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
 - 3. Details of control panel faces, including controls, instruments, and labeling.
 - 4. Written description of sequence of operation.
 - 5. Trunk cable schematic showing programmable control unit locations and trunk data conductors.
 - 6. Listing of connected data points, including connected control unit and input device.
 - 7. System graphics indicating monitored systems, data (connected and cSMSulated) point addresses, and operator notations.

8. System configuration showing peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
- L. Shop Drawings shall be submitted and shall consist of a complete list of equipment and materials, including manufacturer's descriptive and technical literature, catalog cuts, and installation instructions. Shop drawings shall also contain complete wiring, routing, schematic diagrams, tag number of devices, software descriptions, calculations, and any other details required to demonstrate that the system will function properly. Drawings shall show proposed layout and installation of all equipment and the relationship to other parts of the work.
- M. Shop Drawings shall be approved before any equipment is installed. Therefore, shop drawings must be submitted in time for review so that all installations can be completed per the project completion schedule. Ten working days shall be allowed for submittals to be reviewed.
- N. All drawings shall be reviewed after the final system checkout and updated or corrected to provide "as-built" drawings to show exact installation. All shop drawings will be acknowledged in writing before installation is started and again after the final checkout of the system. The system will not be considered complete until the "as-built" drawings have received their final approval. The Contractor shall deliver a complete set of "as-built" drawings.
- O. On submissions beyond the initial one, clearly identify changes made from the initial submittal other than those requested by the Design Professional. The Design Professional will review only those changes he requested and those identified by the Contractor.
- P. If the Contractor elects to proceed to install equipment for which approved Shop Drawings have not been received, he does so at his own risk; Design Professional is not obligated to accept such equipment or work, nor will Design Professional be liable for claimed costs or delays required by correction of such work.

Shop Drawing Review Comment Definitions

A> No Exception Taken:

The shop drawing or equipment submittal as submitted is approved without exception. No changes or corrections required. The materials, equipment or system submitted can be released for fabrication and construction. No Further Submission Required.

B> Make Corrections Noted:

The shop drawing or equipment submittal as submitted is not completely correct but is approved as noted. Make the corrections noted on the shop drawing or submittal. The materials, equipment or system submitted can be released for fabrication and construction once the corrections have been made. The submittal must be corrected and resubmitted for record unless noted by "E: Resubmit". See "E: Resubmit definition below.

C> Submit Specified Item:

The shop drawing or equipment submittal as submitted is missing a component of the system that it represents or is not of the approved and specified manufacturers. Submit the missing or incorrect item. The materials, equipment or system submitted cannot be released for fabrication and construction.

D> No Further Submission Required:

The shop drawing or equipment submittal as submitted is approved as noted. No changes or corrections required. The materials, equipment or system submitted can be released for fabrication and construction. No Further Submission Required.

E> Resubmit:

The shop drawing or equipment submittal as submitted is not approved. The shop drawing or equipment submittal needs significant corrections and does require another submission to verify that the comments and changes have been incorporated. Make the corrections noted on the shop drawing or submittal. The materials, equipment or system submitted cannot be released for fabrication and construction.

F> Rejected:

The shop drawing or equipment submitted is not as specified or a non-approved manufacturer or product and rejected.

G> Resubmit for Record Only:

Make the corrections noted on the shop drawing or submittal. The shop drawing or equipment submittal as submitted is approved with minor exception. Changes or corrections are required. The materials, equipment or system submitted can be released for fabrication and construction.

PART 3 - EXECUTION

3.1 VISIT TO SITE:

- A. Before submitting bid, visit the site of the work and be thoroughly familiarized with the conditions affecting the work. No extra payment will be allowed on account of extra work made necessary by failure to do so.

3.2 WORKMANSHIP:

- A. All work shall be installed in a first class, neat and workmanlike manner by mechanics skilled in the trade involved. All details of the installation shall be mechanically and electrically correct. Should the Design Professional direct removal, change, or installation of any equipment or systems not installed in a neat and workmanlike manner, such charges shall be made by the Electrical Contractor at no expense to the Owner.
- B. Equipment shall be installed in strict accordance with manufacturer's instructions for type and capacity of each piece of equipment used. The Contractor shall obtain these instructions from the manufacturer and these instructions shall be considered part of these Specifications.
- C. Drawings and specifications have been prepared with best knowledge of conditions available at the time of design. If any obscurities or discrepancies exist, they shall be brought to the attention of the Design Professional before bids are submitted. If they are not discovered before bids are submitted, the Design Professional shall be notified and shall render decision. This decision shall be final.

1. Drawings and Specifications are intended to be complementary; items described or shown in one but not both are to be furnished as if fully shown or described in both locations.
 2. In case of conflict between provisions of the Specifications, the more stringent requirement shall govern. Where a requirement is applied to a specific product, condition, system or Specification Section which conflicts with a more general requirement elsewhere, the specific shall supersede the general.
- D. Drawings are generally indicative of the work to be installed, but do not indicate all conduit bends, fittings, boxes, and specialties which may be required, or the exact locations of all conduits. Contractor shall investigate structure and finish conditions affecting his work and arrange his work; accordingly, furnishing such fittings as may be required to meet such conditions. Contractor is responsible for exercising proper judgment to arrange his work and materials so as to avoid interference with other trades.
1. The essentially diagrammatic nature of drawings shall not be interpreted as reason to redesign project. While raceways or cables shall be installed as required by local conditions rather than exactly as shown, all outlets indicated on one circuit shall be so installed. No reduction in size or number of raceways or cables will be permitted, except that it shall be permissible to "gang" two or three sequentially phased 15 or 20 ampere branch circuits to form a single phase, three-wire, or three phase four-wire multiwire branch circuit, per NEC Article 210.4. In general, number of wires in each raceway or cables has not been indicated but shall be provided as required.
 2. Riser diagrams, details, and schematics generally indicate wiring to be used in various systems involved. This information may or may not be duplicated on the plans, but equipment shown on either plans or riser diagrams and schematics shall be provided as if shown on both.
 3. All grades, elevations, dimensions, and clearances of equipment shown on drawings are approximate and shall be verified at site.
 4. Where work or equipment is referred to in singular terms, such reference shall be deemed to apply to as many items of work or equipment as required to complete entire installation.
- E. Electrical junction boxes, pull boxes, panel boards, switches and controls and other apparatus requiring periodic maintenance and operation shall be accessible.
- 3.3 FIELD MEASUREMENTS:
- A. Before ordering any material or doing any work, verify all measurements at the building and site and be responsible for the correctness of same. No extra compensation will be allowed on account of differences between actual dimensions and measurements and those indicated on the drawings. Any difference which may be found shall be submitted to the Design Professional for consideration before proceeding any further with the work.
- 3.4 DELIVERY OF EQUIPMENT:
- A. Be responsible for delivery of equipment, unload and store in a manner not to interfere with the operation of other trades. Additional expense incurred because of equipment or material delivery delays shall be assumed by the responsible Contractor.
- 3.5 PROTECTION OF WORK:
- A. All work, equipment and materials shall be protected at all times. All raceway openings shall be closed with caps or plugs during the installation. All equipment shall be tightly covered and

protected against dirt, water, plaster, paint and other foreign material or mechanical injury during entire progress of installation. Make good all damage caused either directly or indirectly by workmen employed to fulfill requirements of the Electrical Work.

3.6 REMOVAL OF RUBBISH:

- A. During the course of construction, periodically remove from the premises all rubbish resulting from work of this trade so as to prevent its accumulation. At the completion of the work contemplated under these Specifications remove from the building and site all rubbish and accumulated materials of whatever nature not caused by the other trades and leave work, and equipment free of all foreign matter including plaster, cement, and paint and leave in a clean, orderly, acceptable, and usable condition.

3.7 COORDINATION WITH OTHER TRADES:

- A. Work in conjunction with each of the other trades to facilitate proper and intelligent execution of work with minimum interference.
- B. Carefully examine all architectural and structural drawings for the building and drawings for electrical trade and mechanical trades and be responsible for the proper fitting of all material and equipment into the building as planned and without interference with other piping, ductwork, conduit, or equipment. Proper judgment shall be exercised to secure best possible headroom, door and window clearance, and space conditions throughout; to secure neat arrangement for piping, equipment, and conduit, and to overcome all local difficulties and interferences to best advantage. Approval for any and all changes to plans and specifications which may thus be incurred shall be obtained from the Design Professional before proceeding.
- C. Contractor shall prepare preliminary shop drawings suitable for use in coordinating his work with the work of other trades. The HVAC section will prepare and furnish sepia prints at 3/8" = 1'-0" scale with all trades indicating piping, ductwork and conduit in relation to all structural elements of the construction, including floor elevations; steel locations, size, and elevations; partitions locations; door locations and direction of swing; and all other information required to assure coordination of the electrical, sheetmetal and piping trades and fire protection in relation to the Architectural function of the project. Coordination meetings will be held under the supervision of the Owner's Construction Manager and General Contractor. Each trade shall have proper representation at all coordination meetings for the purpose of detailing, on a sepia print mentioned above, the exact location and routing of their work. After the conclusion of the coordination at the working meetings, each trade shall sign the coordinated sepia, copies of which will be distributed by the GC to all contractors and parties concerned including the Owner. Final shop drawings of all trades shall be in accordance with the coordinated drawing, which final shop drawings shall be submitted for final approval.
- D. If contractor installs work so as to cause interference with work of other trades, he shall make necessary changes in work to correct the condition without extra charge.
- E. Dimensional layout plans of equipment rooms shall be made showing all bases, pads and inertia blocks required for mechanical equipment. Include dimensions of bases, bolt layouts, details, etc.
- F. Contractor shall furnish all necessary templates, patterns, etc. for installing work and for purpose of making adjoining work conform, furnish setting plans, and shop details to other trades as required.

3.8 COORDINATION OF ELECTRICAL CHARACTERISTICS:

- A. Electrical Contractor shall carefully examine the drawings of all other trades for equipment requiring electrical connection and shall ascertain that all electrical characteristics of equipment scheduled thereon matches the service available.
- B. If any discrepancies are noted, he shall immediately refer to Design Professional for resolution. If characteristics are correct, Electrical Contractor is responsible for ascertaining method of connection, "rough-in" dimensions, correct plug and receptacle configurations, etc. While Design Professional has made every effort to provide such information as is known at time of design, Contractor shall obtain final data from shop drawings before proceeding.
- C. For all equipment of other trades which electrical characteristics are not scheduled on drawings of that trade, the Electrical Contractor shall assume the responsibility of notifying the Contractor furnishing such equipment as to the characteristics required; Electrical Contractor will be held responsible for correction of all problems arising from failure to do so.

3.9 EQUIPMENT IDENTIFICATION:

- A. All panels, relays, contactors, starters, circuit breakers, safety switches, or similar items shall be identified by equipment name, function, and/or control. Unless otherwise noted, tags shall be engraved plastic black field with white letters. Size of nameplate shall be determined to fit the individual conditions. Nameplates shall be securely and permanently mounted. Use sheet metal screws, drive rivets, or "pop" rivets. Cement or adhesive strips will not be accepted.
- B. Any existing equipment, panels, switchboards, or other items on which work is to be done under this Contact, and which does not have an identifying tag or label, shall be provided with a nameplate as noted in A, by this Contractor.
- C. A schedule of nameplates proposed to be used shall be submitted for approval, and no identification material shall be ordered until approval is received.
- D. Identify electrical conductors in splice or pull boxes, panels, cabinets, or other locations with round or square tags made of heavy paper and fastened with nylon or cotton cord. Such identification shall indicate circuit number; gauge of conductors; and either designation (at source location) or source (at destination and intermediate locations). Lace all conductors of one circuit together prior to tagging.

3.10 FIRE STOPPING:

- A. All penetrations through fire-resistance-rated floor, fire resistance rated, floor/ceiling assemblies and roof construction and through fire-resistance-rated walls and partitions shall be fire stopped.
- B. Penetrations to be fire stopped include both empty openings and those containing cables, pipes, ducts, conduits, and any other items.
- C. Fire rating of sealed penetrations shall meet or exceed the rating of the assembly being penetrated.
- D. Materials shall be installed in accordance with manufacturer's recommendations and their UL listing.

3.11 SEISMIC RESTRAINTS:

- A. All electrical equipment and material required by applicable Codes to be installed or supported in accordance with seismic restraint criteria shall be installed in accordance with this Article. This applies to equipment or materials specified in other Division 16 Specification sections as well as to materials specified in this section.
- B. Seismic restraint calculations must be performed and certified by a registered professional engineer whose practice comprises the design of seismic restraints. Calculations must identify equipment or materials requiring such restraints, and shall include calculated dead loads, derived loads, and materials used for connection to equipment and structures. Analysis shall include anchoring methods, sizes of fasteners and connections, embedment, weld details, etc.
 - 1. The building location is in an area with Effective Peak Velocity Related Acceleration Coefficient (A_v) of _____. The building is in Seismic Hazard Exposure Group _____ and must meet Seismic Performance Category _____.
 - 2. All supports, restraints, fasteners, and attachments shall meet the criteria in subparagraph 1, above, as well as complying with the component Seismic coefficient (C_c) and Performance Criteria Factor (P) for the specific equipment, devices, or system involved.
 - 3. Seismic Engineer shall provide a seismic design Errors and Omissions insurance certificate.
- C. Contractor shall provide hangers, isolators, supports, restraints, etc., from a single manufacturer of such products. Such manufacturer shall certify in writing that the products provided by him meet the requirements specified or calculated by the Seismic Engineer for the specific application. Manufacturer shall be responsible for:
 - 1. Determining restraint sizes and locations.
 - 2. Providing restraint products to meet the requirements of specific application.
 - 3. Guaranteeing performance of the products supplied.
 - 4. Providing installation instructions, drawings, and field supervision to the contractor to ensure proper installation of the products; and
 - 5. Certifying correctness of installation of the products upon completion and identifying for correction any items or areas not properly applied.

3.12 COMMISSIONING

- A. The installing contractor shall provide a field technician and specialized tools to facilitate a successful site system commissioning and testing for all equipment and systems. This contractor and technician shall be part of the overall commissioning team. Where applicable and required, the contractor shall secure and pay for a factory technician to be part of the startup, testing and commissioning team and efforts.
 - 1. All equipment shall be commissioned, and the operation of that equipment shall be checked by the installing contractor. Specific systems shall be commissioned when more than one contractor is involved in the installation or there is multiple system interface and control involved with that piece of equipment.
 - 2. The contractors shall check and verify all equipment nameplate data against the design parameters, prior to installation.
 - 3. The contractors shall submit a Spare Parts List for all equipment in the Maintenance and Operations Manuals to include, but not limited to the following:
 - a. Part Numbers

- b. Part and Equipment Description
- c. Quantity of Parts Required
- d. Lubrication Requirements
- e. Full Warranty Information
- f. Complete Operation and Maintenance Manuals

END OF SECTION

SECTION 260005

COORDINATION DRAWING REQUIREMENTS FOR ELECTRICAL

PART 1 – GENERAL

1.1 COORDINATION DRAWINGS

- A. All mechanical, electrical, plumbing, fire protection, telecommunications, and ATC subcontractors will be required to use AutoCAD (CAD) format. Coordination drawings will be distributed via email and/or disk.

1.2 ABOVE CEILING AND NO CEILING OVERHEAD INSTALLATION

- A. The Mechanical Contractor shall furnish minimum 1/4 inch scale CAD electronic background drawings of the sheet metal shop drawings, for incorporation of plumbing and mechanical piping services. All ductwork and piping systems shall be thoroughly dimensioned as to location and height above finished floor. Each different system will be drawn in a different color. Upon conclusion of the various systems coordination with the Sheet Metal Contractor, the composite drawing shall be distributed by the Construction Manager for contractor coordination. All lighting fixture locations will be “ghosted in” by the Sheet Metal Contractor for coordination of the same. The Sheet Metal Contractor shall prepare a title box on each drawing which allows space for the signature of the authorized individual from the Sheet Metal, HVAC Piping, Plumbing, Fire Protection, Electrical, Telecommunications and ATC firms, with the statement below:

“The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work.”

NOTE: The composite drawing is in addition to separate shop drawings to be submitted at the conclusion of the coordination process.

- B. At the conclusion of each composite drawing coordination process, the Construction Manager shall be notified by the Mechanical Contractor Project Manager. The Mechanical Contractor Project Manager shall then schedule an on-site coordination meeting for the purpose of signing off on the respective drawing. The Mechanical Contractor shall not be authorized to release any material for fabrication or installation until the composite drawing signature process is executed or until Construction Manager authorizes, in writing, a portion of the work to proceed.
- C. The Mechanical Contractor shall print a weekly status log and maintain a file for the project on this process. Each subcontractor is responsible to submit and coordinate his work with the Construction Manager and Mechanical Contractor.
- D. The Fire Protection Contractor shall overlay his complete piping system on a composite background drawing furnished by the Mechanical Contractor. The Fire Protection Contractor shall utilize a different color from that previously used by the HVAC and Plumbing draftsmen. The Fire Protection Contractor shall cooperate in the coordination process by the relocation of his piping as required to facilitate coordination. When completed, Sprinkler Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the entire coordination process, the Fire Protection Contractor shall be responsible for attending a coordination meeting at the jobsite for the purpose of his authorized personnel affixing their signatures to the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

NOTE: The composite drawing is in addition to a separate sprinkler piping shop drawing to be submitted at the conclusion of the coordination process.

- E. The Electrical Contractor shall be responsible to overlay his major conduit racks and equipment, as well as verifying all lighting fixture locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. All conduits larger than 2 inch shall be documented. When completed, Electrical Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Electrical Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of his authorized personnel affixing his signature to the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

- F. The Plumbing Contractor will be responsible to overlay his major piping racks and equipment, as well as verifying all plumbing fixture locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. When completed, Plumbing Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Plumbing Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of his authorized personnel affixing his signature to the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

- G. The Telecommunication Contractor will be responsible to overlay his major communication racks and cable tray, as well as verifying locations and heights for coordination with the other trades on a composite drawing prepared by the Mechanical Contractor. When completed, Telecommunication Contractor's coordination drawing shall be delivered to the Construction Manager. At the conclusion of the coordination drawing process, the Telecommunication Contractor shall be responsible to attend a coordination meeting at the jobsite for the purpose of his authorized personnel affixing his signature to the statement below:

"The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work."

- H. Provide survey and coordination of underground plumbing for verification of location.
- I. Drawings, if available, may be obtained electronically from the Architect through the Construction Manager.
- J. The Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC Contractors shall receive hard copies of all drawings.

- K. The Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC Contractors shall review all drawings and advise if any additional drawings are needed.
- L. The Mechanical Trade Contractor shall take the lead and develop a drawing list for submissions and a submission schedule coordinated with the construction activities. The drawings shall be developed in a sequential fashion so as to no delay installation of the work or the overall project schedule. The lead Mechanical trade contractor shall include a master key plan so that the area of each drawing can be readily identified as to the location within each building. The Plumbing trade contractor shall lead the underground coordination and the HVAC trade contractor shall lead the balance of the coordination work. The drawing list and schedule shall be forwarded to the Construction Manager for review.
- M. Pursuant to Construction Manager approval of the list and schedule, the Mechanical trade contractor shall provide to all participants the latest plans in a timely fashion in accordance with his schedule.
- N. Prior to the start of the work, each subcontractor shall forward an insulation schedule to the Construction Manager M.E.P. Coordinator. The schedule shall show the size and thickness of each type of insulation and its intended use.

1.3 SHEET METAL/PIPING/ATC/ELECTRICAL ACCESS/MAINTENANCE CLEARANCES

- A. As soon as practical, the Mechanical trade contractor shall prepare layout drawings (not less than 3/8 inch scale) of all ductwork and piping. These drawings shall show all WALL FIRE RATINGS, registers, grilles, diffusers and similar features, as well as locations of all valves, dampers, damper operators and other items requiring access for maintenance. It shall also be the responsibility of the Mechanical trade contractor to show on these drawings; beams with bottom elevations, ceiling heights, wall-to-wall dimensions, partitions, columns, windows, doors, electric lighting layouts as shown on the reflected ceiling plans, acoustical ceiling grid, and other major architectural and structural features as shown on the General Construction Drawings. All dimensions should be from centerlines of columns. All required access to equipment for service and/or required for NEC code required clearances shall be shown in a dotted zone.
- B. The Mechanical trade contractor, upon completion of his work, shall email his data back to the Plumbing trade contractor and copy all participants. The Plumbing trade contractor shall download the mechanical data and incorporate, by separate layer, his own routing, as well as other areas requiring access for service and maintenance to determine their relationship and possible interferences with the mechanical, architectural, or structural features to be performed as part of the work.
- C. The Plumbing trade contractor shall then email his data to the Electrical trade contractor and copy all participants. The Electrical trade contractor shall download the drawing and incorporate, by separate layer, his own routings, as well as the depth of all light fixtures, access panels, etc., as required to determine the relationship and possible interferences with plumbing, mechanical, architectural, or structural items to be installed as part of the overall work. The Electrical trade contractor shall be responsible to verify that the electrical lighting layout shown on these drawings is correct and to make corrections and additions of all other light fixtures as required. In areas where no mechanical work occurs, but where other crowded electrical installations are evident, the Electrical trade contractor shall prepare similar drawings.
- D. The Electrical trade contractor shall then email the Fire Protection trade contractor and copy all participants. The Fire Protection trade contractor shall download the drawing and incorporate, by separate layer, his own routings, as well as other areas requiring access for service and

- maintenance, to determine their relationship and possible interferences with the mechanical, electrical, plumbing, and architectural or structural items to be installed as part of the overall work.
- E. The Mechanical trade contractor shall provide one composite set of reproducible drawings and forward them to the Construction Manager. This composite shall then be reviewed during meetings determined by the Construction Manager, at which all subcontractors including their subcontractors, as required by the Construction Manager, shall be represented to review, and resolve any real or apparent interference or conflicts.
- F. In the preparation of all the final composite drawings, large scale details, as well as cross and longitudinal sections shall be made as required to fully delineate all conditions. Particular attention shall be given to the locations, size and clearance dimensions of equipment items, shafts and similar features. The final composite drawings shall include the locations of all controls, tie-ins, connections for other subcontractor's work, and pipe and duct insulation as required.
- G. Final composite drawings shall then be signed off by each trade subcontractor indicating their acceptance and approval of the indicated routings and layouts and their relationship with the adjoining or contiguous work of all subcontracts. Thereafter, no unauthorized deviations shall be permitted. If deviations are made without the knowledge and agreement of Construction Manager and other affected trade contractors, the work in question shall be subject to removal and correction at no additional cost.
- H. In preparing the composite drawings, minor changes in duct, pipe or conduit routings that do not affect the intended function may be made as required to avoid space conflicts, when mutually agreed. Items may not be resized, exposed items relocated, or items run exposed when not intended, without approval. No changes shall be made in any structural members or architectural features which affect the function or aesthetics of the buildings. If conflicts or interferences cannot be satisfactorily resolved, the Engineer shall be notified, and his decision obtained.
- I. After final composite drawings have been accepted and approved, and signed by ALL subcontractors, the Mechanical trade contractor shall provide and distribute one sepia and two prints to each of the subcontractors, and one sepia and four prints each to Construction Manager. Subcontractors requiring further prints for their own distribution will possess sepias to accomplish same. The original signed-off mylars shall be sent to Construction Manager for permanent possession.
- J. The record copies of final composite drawings shall be retained by each subcontractor as a working reference. All shop drawings, prior to their submittal to Construction Manager, shall be compared with the composite drawings and developed accordingly by the subcontractor responsible. Any revisions to the composite drawings, which may become necessary during the process of the work, shall be noted by all subcontractors, and shall be neatly and accurately recorded on the record copies. Each trade contractor shall be responsible for the up-to-date maintenance of his own record copies of the composite drawings and to keep one copy available at the site. The composite drawings and any subsequent changes thereto, shall be utilized by each subcontractor in the development of his as-built drawings. NOTE: The coordination drawings may be used with appropriate changes as as-builts and changes to title block.
- K. Preparation of coordination drawings shall commence as soon as possible after award of the subcontract. The coordination drawings may lack complete data in certain instances pending receipt of equipment drawings, but sufficient space shall be allotted for the items affected. When final information is received, such data shall be promptly inserted on the composite by that trade contractor.
- L. Coordination is the responsibility of all trade contractors. Construction Manager will call meetings, weekly, or as required, which subcontractors must attend to avoid delay. Failure to

attend shall require the trade contractor to field run the work not coordinated. No extra compensation will be paid to any trade contractor for relocating any duct, pipe, conduit, or other material that has been installed without proper coordination. If the installation of any uncoordinated work or improper installation or coordinated work necessitates additional work by other subcontractors, at the cost of such additional work shall be assigned to the trade contractor responsible as determined by Construction Manager.

- M. All changes in the work of any subcontract shall be shown on the composite drawings.
- N. All work on the coordination composite drawings shall be performed by competent CAD operators, in a clear legible manner. Each trade contractor shall execute a typical drawing activity in no more than three working days. It shall be the responsibility of each subcontractor to supply a sufficient number of CAD operators so as not to delay the coordination process. Construction Manager and Engineer shall be the judge of the acceptability of the drawings.
- O. The composite drawings shall not be used for as-built drawings. (See Paragraph above)
- P. It shall be further understood that each trade contractor's specified submittals shall be transmitted for approval during the coordination period in order that the project encounter no delays.
- Q. The Mechanical trade subcontractor shall pre-coordinate all control equipment locations with the designated ATC trade subcontractor and indicate it on the composite document.

1.4 REQUIREMENTS

- A. All Mechanical, Electrical, Plumbing, Fire Protection, Telecommunication and ATC trade contractors shall be required to use AutoCAD (CAD) format. Coordination drawings shall be distributed via email or diskettes. ALL EMAILS SHALL BE COPIED TO CONSTRUCTION MANAGER, ENGINEER, AND PROJECT MANAGER.
- B. The Sheet Metal trade contractor shall prepare a title box on each drawing which allows space for the signature of the authorized individual from the sheet metal, HVAC, piping, plumbing, sprinkler, electrical and ATC firms with the statement below:

“The undersigned individual certifies by their signature that they have coordinated their work with all other work noted on this drawing and the contract documents and shall be held responsible for any costs arising out of their respective inability to fully coordinate their work.”
- C. The Mechanical trade contractor shall not be authorized to release any material for fabrication or installation until the composite drawing signature process is executed or until Construction Manager authorizes, in writing, a portion of the work to proceed.
- D. The Mechanical Contractor shall print a weekly status of all emails sent and received and maintain a hard copy file for use at the coordination “sign-off” meetings. Each subcontractor is required to check emails daily.
- E. Submittals: Once the coordination process has been completed, the coordination drawings shall be submitted to the Engineer for review. A single-color plot, as well as three blueprint copies of the drawings shall be submitted for review. The color plot shall delineate between the various disciplines by utilizing different color pens for each system.

PART 2 – PRODUCTS (NOT APPLICABLE)

PART 3 – EXECUTION (NOT APPLICABLE)

END OF SECTION

SECTION 260005

ACCESS DOORS IN GENERAL CONSTRUCTION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Furnish access doors located in general construction in accordance with the Contract Documents. Access doors in general construction will be installed by the General Contractor. Access doors shall be provided for the operation and maintenance of concealed equipment, pull boxes, LED drivers, etc.

1.2 WORK INCLUDED

- A. Access Doors in Drywalls.
- B. Access Doors in Ceilings.
- C. Access Doors in Masonry.
- D. Fire Rated Access Doors.
- E. Color Coded Buttons.

1.3 REFERENCE STANDARDS

- A. All access doors shall be designed and manufactured in accordance with the latest applicable industry standards and Codes, including the following:
 - 1. Building Code.
 - 2. NEC
 - 3. U.L.

1.4 SUBMITTALS

- A. Provide manufacturer's data on access doors to be furnished in each type of general construction by location within the project.
- B. Access doors, including construction, size; type shall be superimposed on conduit layout shop drawings.

PART 2 - PRODUCTS

- 2.1 Wherever access is required through walls or ceilings to junction boxes, pull boxes, control panels, devices, or other concealed equipment installed under this Division, furnish a hinged access door with flush screwdriver operated cam locks and frame as follows:
 - A. Drywall Construction - Milcor Style DW or equal from J.L. Industries, Karp Associates or Nystrom.

- B. Finished Acoustical Tile Ceiling - Milcor Style AT or equal from J.L. Industries, Karp Associates or Nystrom.
 - C. Finished Plaster Ceiling - Milcor Style AP or equal from J.L. Industries, Karp Associates or Nystrom.
 - D. Finished Plaster Walls - Milcor Style K or equal from J.L. Industries, Karp Associates or Nystrom.
 - E. Rated Walls or Shafts – Milcor UFR or equal from J.L. Industries, Karp Associates or Nystrom.
 - F. Non-rated Masonry or Concrete – Milcor Style M or equal from J.L. Industries, Karp Associates or Nystrom.
 - G. Provide access doors in rated construction with "B" label fire construction. Furnish a U.L. label on each access door.
 - H. Access doors will be installed under another Division. Coordinate all sizes and locations with General Contractor.
 - I. No access door shall be installed until location and type have been approved by the Architect.
- 2.2 Furnish color coded buttons or tabs to indicate location of pull boxes, control panels, devices or other equipment located above removable type ceilings where access doors are not required.
- 2.3 Make access door size a minimum of 24" x 24".
- 2.4 Provide all access doors from the same manufacturer.

PART 3 - EXECUTION

3.1 GENERAL

- A. Coordinate sizes and location of all access doors with General Contractor and Architect.
- B. Direct location and setting of access doors in hung ceilings, furred spaces, walls, etc., to provide access to all concealed work items requiring maintenance and/or adjustment and as directed by the Architect/Engineer. Obtain acceptance of the Architect/Engineer for the locations and sizes of such access doors.
- C. Locate and group equipment requiring access doors so that access door locations are aesthetically acceptable. Coordinate location of equipment requiring access with other trades to minimize number of access doors in one area. Prepare drawings of pull boxes, control panels, devices, etc. locations indicating proposed access door locations for review by the Architect/Engineer prior to the installation of pull boxes, control panels, devices, etc. Include equipment of other trades on the Contract Drawing.
- D. Provide access doors for maintenance or adjustment purposes for electrical system components, including but not limited to the following:
 - 1. Junction and Pull Boxes.
 - 2. Switches and Contactors.
 - 3. Starters and VFDs.

4. Remote Drivers and Lighting Control Modules.

3.2 COLOR CODED IDENTIFICATION

- A. Removable ceiling tile and access doors shall be marked by small color markings at corner of tile or door in accordance with the following color assignments:
 1. Electrical – Blue.
 2. Fire Alarm – Red.
 3. Telephone System – Yellow.

END OF SECTION

SECTION 260270

TEMPORARY LIGHTING AND POWER

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide temporary lighting and power as required for use throughout the duration of construction of the project.

1.2 WORK INCLUDED

- A. Temporary Lighting and Power.

1.3 SUBMITTALS

- A. None required.

1.4 QUALITY ASSURANCE

- A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:
 - 1. Utility Company Standards.
 - 2. Occupational Safety and Health Act (OSHA).
 - 3. UL 1088
 - 4. NFPA 70 Article 590

PART 2 - PRODUCTS

2.1 NOT USED.

PART 3 - EXECUTION

- 3.1 The Contractor shall make all necessary arrangements with the Owner for the new installation of temporary lighting and power services tailored for this project and the setting of temporary meters in accordance with the Utility Company's requirements. The Contractor shall pay for the installation and maintenance of all temporary light and power wiring, including, but not limited to conduits, wire, switches, fuse boxes, receptacles, distribution panel boards, fused disconnect switches, ground fault interruption equipment, fixtures, lamps, fuses and any other incidental material and/or equipment required to provide sufficient illumination and power, as required by the State Labor Board, OSHA, or all other Authorities Having Jurisdiction for all areas of the site where work will be performed by this Contractor, his subcontractors or any other contractors.
- 3.2 Furnish and install one (1) complete set of work LED lamps, including those required for trailers and/or temporary offices. The Contractor shall also furnish and install one (1) complete set of fuses for temporary light and power services, as required. The replacement of burned out and broken light fixtures shall be carried out by those using the trailers and/or offices.

- 3.3 Rubber covered trailers, each 40' long, having plugs, sockets and locked type guards, shall be supplied by this Contractor for use by other Contractors, as required.
- 3.4 Temporary power circuits and outlets, etc. shall be provided in accordance with the power requirements of the various horsepower ratings of the equipment to be installed under all contracts and for temporary motors, elevator, etc. Temporary power required for motor operated tools and appliances to be used by various contractors in construction work, and not to be a part of the permanent equipment shall be provided.
- 3.5 Irrespective of the scheduled working hours for the Electricians, the Electrical Contractor shall maintain and pay the entire regular and overtime labor costs of keeping the temporary light and power system energized from a period of 15 minutes before the established starting time of the building trade which starts work earliest to a period of 15 minutes after the established stopping time of the trade which stops work latest. This shall apply to every working day of the week during the duration of the contract, unless otherwise directed, or until such time that the maintenance of the temporary light and power system is no longer required by reason of the activation of and use of the permanent light and power systems.
- 3.6 When the Electricians are entitled to a holiday and the other building trade workmen are required to work and do not have the same holiday or holidays, the Electrical Contractor shall maintain and pay the entire overtime labor costs of keeping the temporary light and power system energized for the full day or those full days, as the case may be, including the extra 15 minutes before the start and after the close of the working day, as stated in the preceding paragraph.
- 3.7 Should this Contractor or any Contractor require temporary light or power, or both, before or after the hours set forth in the preceding paragraphs, this Contractor or other Contractors shall pay the extra cost of keeping the systems energized and in serviceable condition.
- 3.8 Temporary lighting shall be removed immediately upon the completion of construction or purpose for which the wiring was installed. This Contractor shall replace and repair all damage to the permanent systems, as required, replacing all damaged parts. All temporary wiring not only must be disconnected but also removed from the building, structure, or other location of installation.
- 3.9 When the permanent lighting and power systems are installed and operational, this Contractor shall make the change-over. The cost of making the change-over of the electric services from the temporary lines to service from permanent lines shall be borne by this Contractor.
- 3.10 At no time shall the temporary electrical equipment installation be used for permanent lighting and power services.

END OF SECTION

SECTION 260280

EQUIPMENT CONNECTIONS AND COORDINATION

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide final connections to equipment and coordinate same in accordance with the Contract Documents.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications Sections apply to this Section.

1.3 WORK INCLUDED

- A. Equipment to receive final connections shall include but is not limited to the following:

1. Elevators.
2. Motors and Equipment.
3. Appliances.
4. IT, A/V, Security and Low Voltage Equipment.
5. Dampers, ALDs and VAVs.
6. Owner Furnished Equipment.
7. Kitchen Equipment.
8. Laundry Equipment.
9. Laboratory Equipment.

1.4 SUBMITTALS

- A. None required.

1.5 QUALITY ASSURANCE

- A. Except as modified by governing codes and by the Contract Documents, comply with the latest applicable provisions and latest recommendations of the following:

1. American National Standard Safety Code for Elevators Dumbwaiters and Moving Walks (ANSI A17.1).
2. State Elevator Code.
3. Food and Drug Administration.
4. NFPA 96.
5. NFPA 72 (NEC)

PART 2 - PRODUCTS

- 2.1 Only those products listed in this Division shall be employed.

PART 3 - EXECUTION

3.1 EXAMINATION OF DOCUMENTS

- A. Prior to the submitting of bids, this Contractor shall familiarize himself with all conditions affecting the proposed installation of equipment requiring electrical connections and shall make provisions as to the cost thereof. Failure to comply with the intent of this paragraph shall in no way relieve the Contractor of performing all necessary work required for final electrical connections and equipment and the coordination thereof.
- B. The Contractor must review all Contract Documents related to the equipment requiring electrical connections. By acceptance of this contract, the Contractor acknowledges all the electrical connections required and will be responsible for providing such electrical connections. No extras will be given for failure to include this work in the base contract price.
- C. Connections shall be made in accordance with the manufacturers' recommendations and reviewed shop drawings.

3.2 ELEVATORS

- A. Provide connections for and coordination of elevators including but not limited to the following:
 - 1. Provide heavy-duty, lockable type fused disconnect switches for each elevator. Provide feeders extended and terminated at each elevator controller. Provide and terminate feeders from the elevator controller to each elevator motor. Coordinate feeder requirements with the Elevator Contractor prior to any work. Provide a minimum of one (1) No. 6 AWG ground conductor bonding the drive enclosure chassis, motor frame, controller enclosure, structural building steel and other as applicable for every elevator. Review bonding requirements with the Elevator Vendor prior to any work. Fuse sizes shall be as per the Elevator Vendor's requirements. All fuses shall be time delay current limiting type Class RK1 or equivalent. Location of switches shall be at the elevator machine room entry or as required by the local authority having jurisdiction.
 - 2. An additional disconnect switch shall be provided for any elevator motor where the motor is not in "line of sight" of the fused disconnect switch.
 - 3. Provide dedicated emergency circuits for car lights, fans and outlets. All such circuits are to be served by the building's emergency power when available. Provide separate circuits fed by lockable circuit breakers per car. The disconnecting means shall be located in the machine room and labeled to identify the appropriate elevator number and marked "Car Lights". All branch circuits overcurrent protective device shall be located in the respective machine room per NEC Article 620.
 - 4. Provide at least two (2) 1' x 4' weatherproof LED light fixtures, switch and GFCI duplex receptacle within each elevator pit. The light fixtures and the receptacles shall be on a separate emergency circuits fed by dedicated lockable breakers. All devices in the elevator pits shall be weatherproof. Locate switch adjacent to the pit door or service ladder. Light fixtures shall be equipped with a protective wire guard. For common pits, provide multiple light fixtures unless otherwise noted on the Contract Documents. The Contractor shall provide additional light fixtures at no extra cost where required due to the field conditions or obstructions to achieve a minimum illumination level of 10 foot-candles at the pit floor and at the pit platform.

5. Provide GFCI receptacle and a light switch located within 18" of each machine room door strike. Provide 1' x 2' or 1' x 4' industrial type LED light fixtures with protective wire guards. The light fixtures shall not be circuited to the load side terminals of the GFCI receptacle. Provide lockable type circuit breakers. Contractor shall provide additional light fixtures at no extra cost where required due to the field conditions or obstructions to achieve a minimum illumination level of 20 foot-candles in the elevator machine room.
6. Provide empty 1" raceways from each elevator machine control room to the nearest telephone backboard for telephone communication, confirm conduit size and quantities per the elevator manufacturer's requirements.
7. Provide empty 2" raceways from each elevator controller to each remote elevator status panel. Size and quantity of raceways shall be per the Elevator Vendor's requirements.
8. Provide multiple signals in dedicated 2" conduits from each automatic transfer switch to each elevator control room served by the respective automatic transfer switch. Refer to the Automatic Transfer Switch (ATS) specification section 263623 for additional information. Daisy chaining of ATS control signal cables is not permitted.
9. Provide recall smoke detectors in each elevator lobby; top of each elevator cab shaft; each elevator machine room; and each elevator cab pit.
10. Provide a fire alarm speaker within each elevator cab and appropriate connections at the respective elevator machine room and Fire Alarm System.
11. Provide a firefighter's telephone within each elevator cab and appropriate connections at the respective elevator machine room and Fire Alarm System.
12. Submit selective coordination study of elevator related overcurrent protection devices for the Engineer's review.
13. Provide two (2) No. 18 AWG stranded copper conductors and interconnect the AUX contacts to the disconnect switches and the elevator equipment per the manufacturer's requirements. Provide ¾" conduit as required.
14. Do not locate any component or conduits in elevator machine rooms, which do not serve the elevators.

3.3 MOTORS AND EQUIPMENT

- A. Connections for and coordination of motors and equipment requiring electrical connections shall be included but is not be limited to the following:

1. Install motor controllers and disconnect switches for each motor and each piece of equipment. The Contractor must refer to all other trades' Contract Drawings for location and power requirements of all motors and other equipment. If any discrepancies are found, the Contractor shall include in his base price the more expensive option.
2. Verify that the motor rotation is correct and reconnect if necessary.
3. Provide separate ground conductor in flexible metal conduit so as to provide an electrically continuous ground path. Ground all equipment.
4. Provide motor branch circuit conductors and connections to each individual motor controller and from each controller to the motor through an approved disconnect switch. Make final connection in a minimum of 24-inch length of liquid-tight, flexible metal conduit.
5. Provide all necessary wiring and connections for interlocking, remote and automatic controls. Installation of equipment and wiring shall be in compliance with the manufacturer's recommendations.
6. Where equipment is fed from a branch circuit routed in or under the slab, terminate branch circuit at a junction box on 2-foot rigid conduit stub-up and make final connection to equipment in liquid-tight, flexible metal conduit. Provide suitable knee brace on conduit stub-up.
7. Where equipment is fed from overhead, support conduit feeder descending from ceiling on flanged floor fitting with conduit type fitting connecting to a motor with 24-inch minimum of liquid-tight flexible metal conduit.

8. Where nameplate on equipment indicates fuse protection, the disconnecting means shall be equipped with time delay fuses.
9. Where condensate pumps or other equipment is installed above hung ceilings such equipment shall not be connected via cord & plug and must be hardwired using permanent wiring methods with a local disconnect switch.

3.4 APPLIANCES

- A. Connections for and coordination of appliances shall be included, but is not limited to the following:
1. The basic requirements for motors and equipment specified above shall apply where applicable.
 2. Where cord and plugs are provided with the appliances, this Contractor shall coordinate the receptacle installation to match. Information on the Contract Documents as to a receptacle type is for bidding purposes only.
 3. Direct connected equipment shall be provided with disconnecting means.
 4. Where disconnect switches are required, this Contractor shall coordinate required rating to match the equipment and install per the NEC.

3.5 IT, A/V, SECURITY AND LOW VOLTAGE EQUIPMENT

- A. Connections for and coordination of all IT, A/V, Security and Low Voltage equipment requiring electrical connections shall be included but is not be limited to the following:
1. Provide electrical connections along with receptacles and disconnect switches for each piece of equipment. The Contractor must refer to all other trades' Contract Drawings for location and power requirements of all such equipment. If any discrepancies are found, the Contractor shall include in his base price the more expensive option.
 2. Coordinate all termination requirements with the low voltage Consultant(s) prior to any work.
 3. Provide isolated ground and equipment ground systems where required by the low voltage design.
 4. Provide emergency and/or UPS power where required by the low voltage design.

3.6 DAMPERS, AUTOMATIC LOUVER DAMPERS (ALD) AND VARIABLE AIR VOLUME BOXES (VAV)

- A. Connections for and coordination of all dampers, ALDs and VAVs requiring electrical connections shall be included but is not be limited to the following:
1. Provide electrical connections along with required disconnect switches for each motor. The Contractor must refer to all other trades' Contract Drawings for location and power requirements of all equipment. If any discrepancies are found, the Contractor shall include in his base price the more expensive option.
 2. The Contractor is responsible to include power provisions for all motors indicated on other trade's Contract Drawings. No extras will be given for not including devices indicated on other trade's documents.
 3. The Contractor must coordinate and include in his price power provisions and connections for all large damper assemblies consisting of multiple motors.
 4. No extras will be given for relocated dampers due to field conditions.
 5. Each damper which is connected to the fire alarm system shall each have dedicated fire alarm addressable modules such that each damper has a unique address and can be controlled. Grouping of dampers on a single module is not acceptable.

3.7 OWNER FURNISHED EQUIPMENT

- A. The requirements for equipment furnished by the Owner for installation by this Contractor shall include but is not limited to the following:
1. The coordination of the proper delivery scheduling of such equipment.
 2. The receiving and unloading of such equipment at the property line.
 3. The inspection of such equipment for damage, defacement, corrosion, missing components, etc. at the job site. All deficiencies shall be recorded. Deficiencies occurring after inspection shall be corrected by this Contractor at his cost.
 4. The safe handling at secure storage of such equipment from unloading to the time of permanent installation.
 5. The completion of field make-up of internal wiring as required.
 6. The lamping of equipment, with new lamps.
 7. The installation of accessories on such equipment.
 8. The installation of such equipment including the transportation of the equipment to the installation area, and the installation of all supports, fasteners, canopies, extensions, etc. required to ensure safe support and adaptation to the finished structural, electrical and architectural conditions.
 9. The final connections and grounding to the building electrical system including all necessary labor and materials including but not limited to junction box extensions, lug change outs, wiring, conduit, etc.
 10. The testing of such equipment in its final location.
 11. Provide all disconnecting means for all equipment to match equipment connection methods, such as receptacles, disconnect switches (fused or unfused), etc.

3.8 INSTALLATION OF KITCHEN AND LAUNDRY EQUIPMENT

- A. This Contractor shall complete final field coordination with the kitchen equipment trade/laundry equipment trade as to final equipment locations. No extras will be given for kitchen/laundry equipment relocations due to field conditions.

3.9 KITCHEN/LAUNDRY EQUIPMENT CONNECTIONS

- A. This Contractor shall furnish the following electrical equipment/devices and make the following connections including, but not limited to:
1. All junction boxes, electrical outlets, stainless steel cover plates and switches not built into kitchen/laundry equipment.
 2. All plugs and cords as noted on the kitchen/laundry consultant's schedules.
 3. Furnish and install multi-pole relays; shunt-trip branch circuit breakers or shunt-trip main circuit breakers as indicated; and disconnect switches for fire control system shut-off of kitchen equipment below hoods or ventilators as shown on the Kitchen Consultant's documents or the Electrical Contract Documents.
 4. Disconnect switches or other similar devices as required by Code.
 5. Provide conduit and wiring, installation of electrical devices furnished by the kitchen/laundry equipment trade and interwire between the following:
 - a. Remote refrigeration equipment to evaporative coils.
 - b. Control panels to water-type ventilators and exhaust/supply fans.
 - c. Kitchen exhaust hoods/ventilators to the fire control system and all shut-off devices.
 - d. Signal from the hood fire control system to the local fire alarm panel with a dedicated zone per hood fire control system.
 - e. Gas solenoid valve for fuel shutdown to all cooking items upon activation of the hood fire control system.

6. All electrical panelboards located in kitchen areas shall be recessed into wall partitions with flush mounted stainless steel panel covers.
- B. All outlets and connections shown on the electrical kitchen/laundry Contract Drawings are indicated for kitchen/laundry equipment only. Refer to the Electrical Contract Drawings which indicates the general areas for outlets and devices for general purpose use.
- C. The electrical kitchen/laundry plans indicate outlet type and location, and connection positions and loads. For final rough-in locations, refer to the kitchen/laundry consultant's dimensioned plans.
- D. Internal electrical work for fabricated food service equipment shall be internally wired and connected by the kitchen equipment manufacturer for all kitchen equipment, except as noted. Refer to the Electrical Contract Documents for food service equipment which, because of physical size, will be delivered to the job site in two (2) or more pieces. In such case, this Contractor shall make final connection(s) to make a single piece of food service equipment.
- E. All electrical work for fabricated food service equipment shall be completely wired by the kitchen equipment manufacturer (except as noted above), to a junction box or pull box mounted on the equipment in an accessible position. Final connections between equipment, junction or pull boxes to the electrical panelboard (except as noted) shall be the responsibility of this Contractor.
- F. This Contractor shall furnish and install size, type and quantity of beverage dispensing raceways as indicated on the Electrical Contract Documents. Final connections shall be verified with the Kitchen Consultant.
- G. Electrical Contractor shall furnish and install at all walk-in cooler / freezer locations:
 1. All weatherproof light fixtures, as provided by kitchen equipment Contractor.
 2. All disconnects and switches at the blower coils.
 3. All weatherproof GFCI duplex outlets.
 4. All interconnections for electrical components in the walk-in cooler / freezer compartments.
 5. All interconnections for freezer evaporators and compressors. Verify exact wire sizes with manufacturers specifications.
 6. All fire alarm system devices.
- H. Electrical Contractor shall furnish and install all wiring and conduits for the walk-in cooler/freezer compartments for the following:
 1. Each evaporator coil.
 2. Each weatherproof ceiling light and switch.
 3. Each personnel alarm switch and light.
 4. Each door heater and any drain heaters required.
 5. Each high temperature warning alarm system.
 6. Each GFCI receptacle.
 7. Each fire alarm device.
 8. All penetrations for the required services must be made through the ceiling insulation and are required to be vapor tight. All conduits shall be installed independently and above the walk-in compartments. Do not install conduit runs inside of the walk-in compartments.
- I. Electrical Contractor shall furnish and install all wiring and conduit for inter-wiring between the following exhaust hood / ventilator compartment.
 1. Electrical services to the control panels, exact requirements for the number of wires and electrical service must be verified with the equipment manufacturer and comply with local codes and regulations.

2. Control wiring and conduit from the control panel to each hood section for dampers, solenoids, and lights.
3. Control wiring and conduit from the control panel to exhaust and supply fans. These fans shall be electrically interlocked.
4. Fire systems control interwiring and conduit between the fire suppression systems, control panels and remote fire controls shutoffs.

3.10 INSTALLATION OF LABORATORY EQUIPMENT

- A. This Contractor shall complete final field coordination with the laboratory equipment trade as to final equipment locations. No extras will be given for laboratory equipment relocations due to field conditions.

3.11 LABORATORY EQUIPMENT CONNECTIONS

- A. This Contractor shall furnish the following electrical equipment/devices and make the following connections, but is not limited to:
 1. All junction boxes, electrical outlets, cover plates and switches not built into the laboratory equipment.
 2. All plugs and cords as noted on the Architect's or laboratory consultant's schedules.
 3. Disconnect switches or other similar devices as required by code.
 4. Provide conduit and wiring, installation of electrical devices furnished by laboratory equipment trade and interwire between the following:
 - a. Remote refrigeration equipment to evaporative coils.
 - b. Control panels to ventilators and exhaust/supply fans.
 5. All outdoor equipment shall be weatherproof type.
 6. Kindorf supports for disconnect switches or receptacles either in the hung ceiling or independently mounted to the floor.
- B. The electrical Contract Drawings indicate outlet type and location, and connection positions and loads. For final rough-in locations, refer to the architectural dimensioned plans.
- C. Internal electrical work for fabricated equipment shall be internally wired and connected by the laboratory equipment manufacturer for all equipment.
- D. Final connections between equipment, junction or pull boxes to the electrical panelboard shall be the responsibility of this Contractor. Utilize liquid-tight flexible connections to all equipment which may vibrate.
- E. Electrical Contractor shall furnish and install at all cold rooms/environmental rooms locations:
 1. All weatherproof light fixtures, as provided by equipment Contractor.
 2. All disconnects and switches at the blower coils.
 3. All weatherproof GFCI duplex outlets and wire mold.
 4. All interconnections for electrical components in the walk-in compartments.
 5. All interconnections for evaporators and compressors. Verify exact wire sizes with manufacturers specifications.
 6. Conduit and wiring for monitoring.
 7. All fire alarm system devices.

- F. Electrical Contractor shall furnish and install all wiring and conduits into cold rooms/environmental rooms for the following:
1. Each evaporator coil.
 2. Each weatherproof ceiling light.
 3. Each door heater and any drain heaters required.
 4. Each high temperature warning alarm system.
 5. Each receptacle or wiremold.
 6. Each fire alarm device.
 7. All penetrations for the required services must be made through the ceiling insulation and are required to be vapor tight. All conduits shall run above the compartments. Do not install conduit runs inside of the compartments.

END OF SECTION

SECTION 260519

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper building wire rated 600 V or less.
2. Metal-clad cable, Type MC, rated 600 V or less.
3. Fire-alarm wire and cable.
4. Connectors, splices, and terminations rated 600 V and less.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

- A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. American Insulated Wire Corp.
 2. General Cable Corporation
 3. Southwire Company.
- C. Standards:
 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 2. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- D. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.
- E. Conductor Insulation:
 1. Type THHN and Type THWN-2: Comply with UL 83.
 2. Type XHHW-2: Comply with UL 44.

2.2 METAL-CLAD CABLE, TYPE MC

- A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.

- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Alpha Wire Company.
2. American Bare Conductor.
3. Atkore International (AFC Cable Systems).
4. Belden Inc.
5. Encore Wire Corporation.
6. General Cable Corporation.
7. Okonite Company (The).
8. Service Wire Co.
9. Southwire Company.
10. WESCO.

- C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Comply with UL 1569.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

- D. Circuits:

1. Single circuit.
2. Power-Limited Fire-Alarm Circuits: Comply with UL 1424.

- E. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.

- F. Ground Conductor: Insulated.

- G. Conductor Insulation:

1. Type TFN/THHN/THWN-2: Comply with UL 83.
2. Type XHHW-2: Comply with UL 44.

- H. Armor: Steel, interlocked.

- I. Jacket: PVC applied over armor.

- J. MC-Lite aluminum armored cable shall not be allowed to be used on this project.

2.3 FIRE-ALARM WIRE AND CABLE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Allied Wire & Cable Inc.
2. CommScope, Inc.
3. Comtran Corporation.
4. Genesis Cable Products; Honeywell International, Inc.
5. nVent (PYROTENAX).
6. Prysmian Group North America.
7. Radix Wire.
8. Rockbestos-Suprenant Cable Corp.

9. Superior Essex Inc.
 10. West Penn Wire.
- B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
- C. Signaling Line Circuits: Twisted, shielded pair, not less than No. 18 AWG.
1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire-alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a two-hour rating.
- D. Non-Power-Limited Circuits: Solid-copper conductors with 600 V rated, 75 deg C, color-coded insulation, and complying with requirements in UL 2196 for a two-hour rating.
1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
 2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.
 3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket] with red identifier stripe, NRTL listed for fire-alarm and cable tray installation, plenum rated.
- 2.4 CONNECTORS AND SPLICES
- A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. 3M Electrical Products.
 2. ABB (Electrification Products Division).
 3. Appleton - O-Z/Gedney; Emerson Electric Co., Automation Solutions.
 4. Atkore International (AFC Cable Systems).
 5. Gardner Bender.
 6. Hubbell Incorporated, Power Systems.
 7. Ideal Industries, Inc.
 8. ILSCO.
 9. NSi Industries LLC.
 10. Service Wire Co.
 11. TE Connectivity Ltd.
- C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.
- D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
1. Material: Copper or Aluminum.
 2. Type: One or Two hole with standard barrels.
 3. Termination: Compression.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders:
 - 1. Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits:
 - 1. Copper, Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- C. Power-Limited Fire Alarm and Control: Solid for No. 12 AWG and smaller.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.
- B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN/THWN-2, single conductors in raceway, or Metal-clad cable, Type MC after the first device in the circuit.
- C. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway, or Metal-clad cable, Type MC after the first device in the circuit.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
- C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
- F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.4 INSTALLATION OF FIRE-ALARM WIRE AND CABLE

- A. Comply with NFPA 72.
- B. Wiring Method: Install wiring in metal pathway according to Section 280528 "Pathways for Electronic Safety and Security."
 - 1. Install plenum cable in environmental airspaces, including plenum ceilings.

2. Fire-alarm circuits and equipment control wiring associated with fire-alarm system must be installed in a dedicated pathway system.
 - a. Cables and pathways used for fire-alarm circuits, and equipment control wiring associated with fire-alarm system, may not contain any other wire or cable.
 3. Fire-Rated Cables: Use of two-hour, fire-rated fire-alarm cables, NFPA 70, Types MI and CI, is permitted.
 4. Signaling Line Circuits: Power-limited fire-alarm cables must not be installed in the same cable or pathway as signaling line circuits.
- C. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with fire-alarm system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- D. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
- E. Color-Coding: Color-code fire-alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire-alarm system junction boxes and covers red.

3.5 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inch slack.

3.6 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor and identify as spare conductor.

3.7 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.8 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

END OF SECTION

SECTION 260526

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Grounding and bonding conductors.
2. Grounding and bonding clamps.
3. Grounding and bonding bushings.
4. Grounding and bonding hubs.
5. Grounding and bonding connectors.
6. Intersystem bonding bridge grounding connector.
7. Grounding and bonding busbars.
8. Grounding (earthing) electrodes.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product indicated.

B. Shop Drawings: Plans showing dimensioned locations of grounding features described in "Field Quality Control" Article, including the following:

1. Test wells.
2. Rod electrodes.
3. Ring electrodes.
4. Grounding arrangements and connections for separately derived systems.

C. Field Quality-Control Submittals:

1. Field quality-control reports.

D. Sustainable Design Submittals:

1. Environmental Product Declaration: For each product.
2. Health Product Declaration: For each product.
3. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
4. Product Data: For each conductor and cable indicating lead content.

1.3 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. In addition to items specified in Section 260010 "Supplemental Requirements for Electrical," include the following:

- a. Plans showing locations of grounding features described in "Field Quality Control" Article, including the following:
 - 1) Test wells.
 - 2) Rod electrodes.
 - 3) Ring electrodes.
 - 4) Grounding arrangements and connections for separately derived systems.
- b. Instructions for periodic testing and inspection of grounding features at test wells, ring electrodes, and grounding connections for separately derived systems based on NFPA 70B.
 - 1) Tests must determine if ground-resistance or impedance values remain within specified maximums, and instructions must recommend corrective action if values do not.
 - 2) Include recommended testing intervals.

PART 2 - PRODUCTS

2.1 GROUNDING AND BONDING CONDUCTORS

A. Equipment Grounding Conductor:

1. General Characteristics: 600 V, THHN/THWN-2 or THWN-2, copper wire or cable, green color, in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Isolated Equipment Grounding Conductor:

1. General Characteristics: 600 V, THHN/THWN-2 or THWN-2, copper wire or cable, green color with one or more yellow stripes, in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. ASTM - Bare Copper Grounding and Bonding Conductor:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ERICO; brand of nVent Electrical plc.
 - b. Harger Lightning & Grounding; business of Harger, Inc.
2. Referenced Standards: Complying with one or more of the following:
 - a. Soft or Annealed Copper Wire: ASTM B3
 - b. Concentric-Lay Stranded Copper Conductor: ASTM B8.
 - c. Tin-Coated Soft or Annealed Copper Wire: ASTM B33.
 - d. 19-Wire Combination Unilay-Stranded Copper Conductor: ASTM B787/B787M.

D. UL KDER - Armored Grounding Wire:

1. Description: Single corrosion-resistant copper, aluminum, or copper-clad aluminum conductor within helically formed steel armor.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. LS Cable & System USA; subsidiary of LS Corp.
 - b. Southwire Company, LLC.
 - c. Superior Essex Inc.; subsidiary of LS Corp.
 - d. Viakon; brand of Conductores Monterrey S.A. de C.V.; a subsidiary of Xignux.
3. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
4. Listing Criteria:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

E. UL KDSH - Protector Grounding Conductor:

1. Description: Conductors intended to be used for grounding primary protector or metallic members of cable sheath in accordance with Chapters 7 and 8 of NFPA 70.
2. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Superior Essex Inc.; subsidiary of LS Corp.
3. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
4. Listing Criteria:
 - a. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
5. Options:
 - a. Color: green.

2.2 GROUNDING AND BONDING CLAMPS

- A. Description: Clamps suitable for attachment of grounding and bonding conductors to grounding electrodes, pipes, tubing, and rebar. Grounding and bonding clamps specified in this article are also suitable for use with communications applications; see Section 270526 "Grounding and Bonding for Communications Systems," for selection and installation guidelines.
- B. Performance Criteria:
 1. Regulatory Requirements:

- a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
 - 2. Listing Criteria:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
 - 3. Sustainability Characteristics:
 - a. Lead Content: Less than 300 parts per million.
- C. UL KDER and KDSH - Hex-Fitting-Type Pipe and Rod Grounding and Bonding Clamp:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. America Fujikura Ltd. (AFL); Fujikura Ltd.
 - c. Arlington Industries, Inc.
 - d. Cooper B-line; brand of Eaton, Electrical Sector.
 - e. Crouse-Hinds; brand of Eaton, Electrical Sector.
 - f. ERICO; brand of nVent Electrical plc.
 - g. Galvan Industries, Inc.; Electrical Products Division, LLC.
 - h. Greaves Corp.; Essex Products Group, Inc.
 - i. Harger Lightning & Grounding; business of Harger, Inc.
 - j. ILSCO.
 - k. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
 - l. Panduit Corp.
 - m. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - 2. General Characteristics:
 - a. Two pieces with zinc-plated bolts.
 - b. Clamp Material: Silicon bronze.
 - c. Listed for outdoor use.
- D. UL KDER and KDSH - U-Bolt-Type Pipe and Rod Grounding and Bonding Clamp:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. America Fujikura Ltd. (AFL); Fujikura Ltd.
 - c. Arlington Industries, Inc.
 - d. Cooper B-line; brand of Eaton, Electrical Sector.
 - e. Crouse-Hinds; brand of Eaton, Electrical Sector.
 - f. ERICO; brand of nVent Electrical plc.
 - g. Galvan Industries, Inc.; Electrical Products Division, LLC.
 - h. Greaves Corp.; Essex Products Group, Inc.
 - i. Harger Lightning & Grounding; business of Harger, Inc.

- j. ILSCO.
- k. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
- l. Panduit Corp.
- m. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics:

- a. Clamp Material: Aluminum.
- b. Listed for outdoor use.

E. UL KDER and KDSH - Strap-Type Pipe and Rod Grounding and Bonding Clamp:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
- b. Crouse-Hinds; brand of Eaton, Electrical Sector.
- c. ERICO; brand of nVent Electrical plc.
- d. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
- e. Panduit Corp.

2. General Characteristics:

- a. Clamp Material: Aluminum.
- b. Listed for outdoor use.

F. UL KDER - Beam Grounding and Bonding Clamp:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. ABB, Electrification Business.
- b. Anderson; brand of Hubbell Utility Solutions; Hubbell Incorporated.
- c. Panduit Corp.
- d. Penn-Union Corp.; subsidiary of Nesco, Inc.

2. General Characteristics: Mechanical-type, terminal, ground wire access from four directions; with dual, tin-plated or silicon bronze bolts.

G. UL KDER - Exothermically Welded Connection:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. ABB, Electrification Business.
- b. ALLTEC LLC.
- c. Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated.
- d. Crouse-Hinds; brand of Eaton, Electrical Sector.
- e. ERICO; brand of nVent Electrical plc.
- f. Harger Lightning & Grounding; business of Harger, Inc.

2. General Characteristics: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

H. UL KDER - Raised-Floor Signal Reference Grid Clamp <Insert drawing designation>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - c. Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated.
 - d. Cooper B-line; brand of Eaton, Electrical Sector.
 - e. ERICO; brand of nVent Electrical plc.
 - f. Harger Lightning & Grounding; business of Harger, Inc.
2. General Characteristics: Mechanical-type, stamped-steel terminal with hex head screw.

2.3 GROUNDING AND BONDING BUSHINGS

- A. Description: Bonding bushings connect conduit fittings, tubing fittings, threaded metal conduit, and unthreaded metal conduit to metal boxes and equipment enclosures and have one or more bonding screws intended to provide electrical continuity between bushing and enclosure. Grounding bushings have provision for connection of bonding or grounding conductor and may or may not also have bonding screws.
- B. Performance Criteria:
 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
 2. Listing Criteria:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
- C. UL KDER - Bonding Bushing:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Arlington Industries, Inc.
 - c. Crouse-Hinds; brand of Eaton, Electrical Sector.
 - d. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - e. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
 - f. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 2. General Characteristics: Threaded bushing with insulated throat.
- D. UL KDER - Grounding Bushing:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Arlington Industries, Inc.
 - c. Crouse-Hinds; brand of Eaton, Electrical Sector.
 - d. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - e. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
 - f. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
2. General Characteristics: Threaded bushing with insulated throat and mechanical-type wire terminal.

2.4 GROUNDING AND BONDING HUBS

- A. Description: Hubs with certified grounding or bonding locknut.
- B. Performance Criteria:
 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
 2. Listing Criteria:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
- C. UL KDER - Grounding and Bonding Hub:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Arlington Industries, Inc.
 - c. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - d. Crouse-Hinds; brand of Eaton, Electrical Sector.
 - e. Greaves Corp.; Essex Products Group, Inc.
 - f. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
 - g. Penn-Union Corp.; subsidiary of Nesco, Inc.
 2. General Characteristics: Insulated, gasketed, watertight hub with mechanical-type wire terminal.

2.5 GROUNDING AND BONDING CONNECTORS

- A. Performance Criteria:
 1. Regulatory Requirements:

- a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
 2. Listing Criteria:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
 - b. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.
- B. UL KDER - Pressure-Type Grounding and Bonding Busbar Cable Connector:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 2. General Characteristics: Copper or copper alloy, for compression bonding of one or more conductor directly to copper busbar. Listed for direct burial.
- C. UL KDER - Lay-In Lug Mechanical-Type Grounding and Bonding Busbar Terminal:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Chatsworth Products, Inc.
 - c. Greaves Corp.; Essex Products Group, Inc.
 - d. ILSCO.
 2. General Characteristics: Mechanical-type, aluminum terminal with set screw.
- D. UL KDER - Crimped Lug Pressure-Type Grounding and Bonding Busbar Terminal:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Harger Lightning & Grounding; business of Harger, Inc.
 - c. ILSCO.
 2. General Characteristics: Cast silicon bronze, solderless compression-type wire terminals; with long barrel and two holes spaced on 5/8 or 1 inch centers for two-bolt connection to busbar.
- E. UL KDER - Split-Bolt Service-Post Pressure-Type Grounding and Bonding Busbar Terminal:
 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Panduit Corp.

2. General Characteristics: Bolts that surround cable and bond to cable under compression when nut is tightened after assembly is screwed into busbar opening.

F. UL KDER - Crimped Pressure-Type Grounding and Bonding Cable Connector:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - c. ILSCO.
 - d. allG Fabrication (formerly ALT).
2. General Characteristics: Crimp-and-compress connectors that bond to conductor when connector is compressed around conductor.
 - a. Copper, C and H shaped.

G. UL KDER - Split-Bolt Pressure-Type Grounding and Bonding Cable Connector:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. ERICO; brand of nVent Electrical plc.
 - c. Greaves Corp.; Essex Products Group, Inc.
 - d. allG Fabrication (formerly ALT).
2. General Characteristics: Bolts that surround cable and bond to cable under compression when nut is tightened.
 - a. Copper.

H. UL KDER - Signal Reference Grid Grounding and Bonding Connector:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated.
 - c. Cooper B-line; brand of Eaton, Electrical Sector.
 - d. ERICO; brand of nVent Electrical plc.
 - e. Harger Lightning & Grounding; business of Harger, Inc.
2. General Characteristics: Combination of compression wire connectors, access floor grounding clamps, bronze U-bolt grounding clamps, and copper split-bolt connectors, designed for the purpose.

2.6 INTERSYSTEM BONDING BRIDGE GROUNDING CONNECTORS

- A. Description: Devices that provide means for connecting communications systems grounding and bonding conductors at service equipment or at disconnecting means for buildings or structures.

B. Performance Criteria:

1. Regulatory Requirements:

- a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2. Listing Criteria:

- a. Grounding and Bonding Equipment for Communications: UL CCN KDSH; including UL 467.

C. UL KDSH - One-Piece Intersystem Bonding Bridge Grounding Connector:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Galvan Industries, Inc.; Electrical Products Division, LLC.
- b. Madison Electric Products; business of Southwire Company, LLC.

2. General Characteristics: Zinc-alloy one-piece construction; six terminating points; gangable.

D. UL KDSH - Two-Piece Intersystem Bonding Bridge Grounding Connector:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Burndy; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
- b. Crouse-Hinds; brand of Eaton, Electrical Sector.
- c. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.

2. General Characteristics: Zinc-alloy body and polycarbonate cover; four terminating points.

2.7 GROUNDING AND BONDING BUSBARS

A. Description: Miscellaneous grounding and bonding device that serves as common connection for multiple grounding and bonding conductors.

B. Performance Criteria:

1. Regulatory Requirements:

- a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.

2. Listing Criteria:

- a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.

3. Sustainability Characteristics:

- a. Lead Content: Less than 300 parts per million.

C. UL KDER - Equipment Room Grounding and Bonding Busbar:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Chatsworth Products, Inc.
 - b. Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated.
 - c. Cooper B-line; brand of Eaton, Electrical Sector.
 - d. ERICO; brand of nVent Electrical plc.
 - e. Harger Lightning & Grounding; business of Harger, Inc.
 - f. Hoffman; brand of nVent Electrical plc.
 - g. ILSCO.
 - h. Panduit Corp.
 - i. allG Fabrication (formerly ALT).
2. General Characteristics:
 - a. Bus: Rectangular bar of annealed copper.
 - b. Mounting Stand-Off Insulators: Lexan or PVC.
 - 1) Comply with UL 891 for use in 600 V switchboards, impulse tested at 5000 V.
3. Options:
 - a. Dimensions: 1/4 by 4 inch in cross section; length as indicated on Drawings.
 - b. Predrilled Hole Pattern: 9/32 inch holes spaced 1-1/8 inch apart.
 - c. Mounting Hardware: Stand-off brackets that provide 2 inch clearance to access rear of bus. Brackets and bolts must be stainless steel.

D. UL KDER - Rack and Cabinet Bonding Busbar:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Chatsworth Products, Inc.
 - b. Cooper B-line; brand of Eaton, Electrical Sector.
 - c. Harger Lightning & Grounding; business of Harger, Inc.
 - d. Hoffman; brand of nVent Electrical plc.
 - e. Panduit Corp.
2. General Characteristics:
 - a. Bus: Rectangular bar of hard-drawn solid copper.
 - b. Horizontal Mounting Dimensions: Designed for mounting in 19 inch wide equipment racks or cabinets.
 - c. Vertical Mounting Dimensions: Designed for mounting in 72 inch high equipment racks or cabinets.
 - d. Predrilled Hole Pattern: Accepts connectors for grounding and bonding conductor sizes 14 AWG to 2/0 AWG.
 - e. Mounting Hardware: Stainless steel or copper-plated, for attachment to rack.

2.8 GROUNDING (EARTHING) ELECTRODES

- A. Description: Grounding electrodes include rod electrodes, ring electrodes, metal underground water pipes, metal building frames, concrete-encased electrodes, and pipe and plate electrodes.
- B. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
 - 2. Listing Criteria:
 - a. Grounding and Bonding Equipment: UL CCN KDER; including UL 467.
- C. UL KDER - Rod Electrode:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Continental Industries; brand of Hubbell Utility Solutions; Hubbell Incorporated.
 - c. ERICO; brand of nVent Electrical plc.
 - d. Galvan Industries, Inc.; Electrical Products Division, LLC.
 - e. Harger Lightning & Grounding; business of Harger, Inc.
 - f. allG Fabrication (formerly ALT).
 - 2. General Characteristics: Copper-clad; 3/4 inch by 10 ft.
- D. UL KDER - Plate Electrode:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ALLTEC LLC.
 - b. Galvan Industries, Inc.; Electrical Products Division, LLC.
 - 2. General Characteristics: 1/4 inch thick, hot-dip galvanized.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine facility's grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of electrical system.
- B. Inspect test results of grounding system measured at point of electrical service equipment connection.

- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with connection of electrical service equipment only after unsatisfactory conditions have been corrected.

3.2 SELECTION OF BUSBARS

- A. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus horizontally, on insulated spacers 2 inch minimum from wall, 6 inch above finished floor unless otherwise indicated.
 - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

3.3 SELECTION OF GROUNDING AND BONDING CONDUCTORS

- A. Conductors: Install solid conductor for 8 AWG and smaller, and stranded conductors for 6 AWG and larger unless otherwise indicated.
- B. Custom-Length Insulated Equipment Bonding Jumpers: 6 AWG, 19-strand, Type THHN.
- C. Bonding Cable: 28 kcmil, 14 strands of 17 AWG conductor, 1/4 inch in diameter.
- D. Bonding Conductor: 4 AWG or 6 AWG, stranded conductor.
- E. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.
- F. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.
- G. Underground Grounding Conductors: Install bare tinned-copper conductor, 2/0 AWG minimum.
 - 1. Bury at least 30 inch below grade.
 - 2. Duct-Bank Grounding Conductor: Bury 12 inch above duct bank when indicated as part of duct-bank installation.

3.4 SELECTION OF CONNECTORS

- A. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.

3.5 SELECTION OF SIGNAL REFERENCE GRIDS

- A. Access Floor Signal Reference Grid:
 - 1. Install 6 AWG bonding conductors in a grid pattern under floor.

- a. Install grid bonding conductors on 4 ft centers, so as to permit bonding of one structural pedestal for each access floor tile. Connect grid conductors together where they cross each other.

3.6 INSTALLATION

A. Comply with manufacturer's published instructions.

B. Reference Standards:

1. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor and install in conduit.
2. Consult Architect for resolution of conflicting requirements.

C. Special Techniques:

1. Conductors:

- a. Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

2. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

- a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
- b. Make connections with clean, bare metal at points of contact.
- c. Make aluminum-to-steel connections with stainless steel separators and mechanical clamps.
- d. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
- e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
- f. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.

- 1) Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate adjacent parts.
- 2) Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
- 3) Use exothermic-welded connectors for outdoor locations; if disconnect-type connection is required, use bolted clamp.

g. Grounding and Bonding for Piping:

- 1) Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to

main metal water service pipes; use bolted clamp connector or bolt lug-type connector to pipe flange by using one of lug bolts of flange. Where dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

- 2) Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with bolted connector.
- 3) Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

- h. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.
- i. Grounding for Steel Building Structure: Install driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 ft apart.

3. Electrodes:

- a. Ground Rods: Drive rods until tops are 2 inch below finished floor or final grade unless otherwise indicated.
 - 1) Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
 - 2) Use exothermic welds for below-grade connections.
- b. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least same distance from other grounding electrodes, and connect to service grounding electrode conductor.
- c. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and must be at least 12 inch deep, with cover.
 - 1) Install at least one test well for each service unless otherwise indicated. Install at ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- d. Ring Electrode: Install grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around perimeter of building.
 - 1) Install tinned-copper conductor not less than 2/0 AWG for ring electrode and for taps to building steel.
 - 2) Bury ring electrode not less than 24 inch from building's foundation.
- e. Concrete-Encased Electrode (Ufer Ground):
 - 1) Fabricate in accordance with NFPA 70; use minimum of 20 ft of bare copper conductor not smaller than 4 AWG.
 - a) If concrete foundation is less than 20 ft long, coil excess conductor within base of foundation.

- b) Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.
 - 2) Fabricate in accordance with NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 ft long. If reinforcing is in multiple pieces, connect together by usual steel tie wires or exothermic welding to create required length.
- 4. Grounding at Service:
 - a. Equipment grounding conductors and grounding electrode conductors must be connected to ground bus. Install main bonding jumper between neutral and ground buses.
- 5. Grounding Separately Derived Systems:
 - a. Generator: Install grounding electrode(s) at generator location. Electrode must be connected to equipment grounding conductor and to frame of generator.
- 6. Grounding Underground Distribution System Components:
 - a. Duct-Bank Grounding Conductor: Bury 12 inch above duct bank when indicated as part of duct-bank installation.
 - b. Comply with IEEE C2 grounding requirements.
 - c. Grounding Manholes and Handholes: Install driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inch will extend above finished floor. If necessary, install ground rod before manhole is placed and provide 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inch above to 6 inch below concrete. Seal floor opening with waterproof, nonshrink grout.
 - d. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields in accordance with manufacturer's published instructions with splicing and termination kits.
 - e. Pad-Mounted Transformers and Switches: Install two ground rods and ring electrode around pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than 2 AWG for ring electrode and for taps to equipment grounding terminals. Bury ring electrode not less than 6 inch from foundation.
- 7. Equipment Grounding:
 - a. Install insulated equipment grounding conductors with feeders and branch circuits.
 - b. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

- 1) Feeders and branch circuits.
 - 2) Lighting circuits.
 - 3) Receptacle circuits.
 - 4) Single-phase motor and appliance branch circuits.
 - 5) Three-phase motor and appliance branch circuits.
 - 6) Flexible raceway runs.
 - 7) Armored and metal-clad cable runs.
 - 8) Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
 - 9) X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.
- c. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- d. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- e. Isolated Grounding Receptacle Circuits: Install insulated equipment grounding conductor connected to receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of applicable derived system or service unless otherwise indicated.
- f. Isolated Equipment Enclosure Circuits: For designated equipment supplied by branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure and install separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of applicable derived system or service unless otherwise indicated.
- g. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.
- h. Metallic Fences: Comply with requirements of IEEE C2.
- 1) Grounding Conductor: Bare, tinned copper, not less than 8 AWG.
 - 2) Gates: Must be bonded to grounding conductor with flexible bonding jumper.
 - 3) Barbed Wire: Strands must be bonded to grounding conductor.
8. Fence Grounding: Install at maximum intervals of 1500 ft except as follows:
- a. Fences within 100 ft of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 ft.
- 1) Gates and Other Fence Openings: Ground fence on each side of opening.
 - a) Bond metal gates to gate posts.
 - b) Bond across openings, with and without gates, except at openings indicated as intentional fence discontinuities. Use 2 AWG wire and bury it at least 18 inch below finished grade.

- b. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at maximum distance of 150 ft on each side of crossing.
- c. Grounding Method: At each grounding location, drive grounding rod vertically until top is 6 inch below finished grade. Connect rod to fence with 6 AWG conductor. Connect conductor to each fence component at grounding location.
- d. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.
- e. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground fence and bond fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

3.7 FIELD QUALITY CONTROL

- A. Field tests and inspections must be witnessed by authorities having jurisdiction.
- B. Tests and Inspections:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with calibrated torque wrench in accordance with manufacturer's published instructions.
 - 3. Test completed grounding system at each location where maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method in accordance with IEEE Std 81.
 - c. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.
 - 4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to record of tests and observations. Include number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- C. Nonconforming Work:
 - 1. Grounding system will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace defective components and retest.
- D. Collect, assemble, and submit test and inspection reports.
 - 1. Report measured ground resistances that exceed the following values:
 - a. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 Ω .

- b. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 Ω .
- c. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 Ω .
- d. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 Ω .
- e. Substations and Pad-Mounted Equipment: 5 Ω .
- f. Manhole Grounds: 10 Ω .

3.8 PROTECTION

- A. After installation, protect grounding and bonding cables and equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION

SECTION 260529

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

- 1. Steel slotted support systems.
- 2. Aluminum slotted support systems.
- 3. Nonmetallic slotted support systems.
- 4. Conduit and cable support devices.
- 5. Support for conductors in vertical conduit.
- 6. Structural steel for fabricated supports and restraints.
- 7. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
- 8. Fabricated metal equipment support assemblies.

- B. Related Requirements:

- 1. Section 260548.16 "Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

- 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
 - a. Slotted support systems, hardware, and accessories.
 - b. Clamps.
 - c. Hangers.
 - d. Sockets.
 - e. Eye nuts.
 - f. Fasteners.
 - g. Anchors.
 - h. Saddles.
 - i. Brackets.
- 2. Include rated capacities and furnished specialties and accessories.

- B. Shop Drawings: [Signed and sealed by a qualified professional engineer.] For fabrication and installation details for electrical hangers and support systems.
 - 1. Hangers. Include product data for components.
 - 2. Slotted support systems.
 - 3. Equipment supports.
 - 4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
- C. Delegated-Design Submittal: For hangers and supports for electrical systems.
 - 1. Include design calculations and details of hangers.
 - 2. Include design calculations for seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Suspended ceiling components.
 - 2. Ductwork, piping, fittings, and supports.
 - 3. Structural members to which hangers and supports will be attached.
 - 4. Size and location of initial access modules for acoustical tile.
 - 5. Items penetrating finished ceiling, including the following:
 - a. Luminaires.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Projectors.
- B. Seismic Qualification Data: Certificates, for hangers and supports for electrical equipment and systems, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M.
 - 2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.
- B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified [and the supported equipment and systems will be fully operational after the seismic event]."
 - 2. Component Importance Factor: 1.5.
- C. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame Rating: Class 1.
 - 2. Self-extinguishing according to ASTM D635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB (Electrification Products Division).
 - b. Atkore International (Allied Tube & Conduit).
 - c. Atkore International (Unistrut).
 - d. Eaton (B-line).
 - e. Flex-Strut Inc.
 - f. Gripple Inc.
 - g. GS Metals Corp.
 - h. G-Strut.
 - i. Haydon Corporation.
 - j. Metal Ties Innovation.
 - k. MIRO Industries.
 - l. nVent (CADDY).
 - m. Wesanco, Inc.
 - 2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 - 3. Material for Channel, Fittings, and Accessories: Galvanized steel.
 - 4. Channel Width: Selected for applicable load criteria.
 - 5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - 7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

- B. Aluminum Slotted Support Systems: Extruded-aluminum channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB (Electrification Products Division).
 - b. Atkore International (Unistrut).
 - c. Cooper Industries, Inc.
 - d. Flex-Strut Inc.
 - e. Haydon Corporation.
 - f. MKT Metal Manufacturing.
 2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 3. Channel Material: 6063-T5 aluminum alloy.
 4. Fittings and Accessories Material: 5052-H32 aluminum alloy.
 5. Channel Width: Selected for applicable load criteria.
 6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Hilti, Inc.
 - 2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.
 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.

- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Eaton (B-line).
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti, Inc.
 - 4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.
- 3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
- 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
- 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325.
- 6. Toggle Bolts: Stainless-steel springhead type.
- 7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
 - 1. NECA 1.
 - 2. NECA 101
 - 3. NECA 102.
 - 4. NECA 105.
 - 5. NECA 111.
- B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted [or other] support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with single-bolt conduit clamps.

- F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings, and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, according to NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners.
 - 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
 - 6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts. Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
 - 7. To Light Steel: Sheet metal screws.
 - 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate [by means that comply with seismic-restraint strength and anchorage requirements].
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

END OF SECTION

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SECTION 260533

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

- 1. Metal conduits and fittings.
 - 2. Metal wireways and auxiliary gutters.
 - 3. Surface raceways.
 - 4. Boxes, enclosures, and cabinets.

- B. Related Requirements:

- 1. Section 078413 "Penetration Firestopping" for firestopping at conduit and box entrances.
 - 2. Section 270528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.

1.3 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.
- C. Samples: For wireways and surface raceways and for each color and texture specified, 12 inches long.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
 - 1. Structural members in paths of conduit groups with common supports.

2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
- B. Qualification Data: For professional engineer.
- C. Seismic Qualification Data: Certificates, for enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.
- D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB (Electrification Products Division).
 - b. Anamet Electrical, Inc (Anaconda Sealite).
 - c. Atkore International (AFC Cable Systems).
 - d. Atkore International (Allied Tube & Conduit).
 - e. Atkore International (Calconduit).
 - f. Electri-Flex Company.
 - g. Emerson Electric Co. (Automation Solutions - Appleton - O-Z/Gedney).
 - h. FSR Inc.
 - i. Korkap.
 - j. NEC, Inc.
 - k. NewBasis.
 - l. Opti-Com Manufacturing Network, Inc (OMNI).
 - m. Patriot Aluminum Products, LLC.
 - n. Perma-Cote.
 - o. Plasti-Bond.
 - p. Republic Conduit.
 - q. Southwire Company.
 - r. Topaz Lighting & Electric.
 - s. Western Tube and Conduit Corporation.
 - t. Wheatland Tube Company.
 - u. Zekelman Industries (Picoma).
2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. GRC: Comply with ANSI C80.1 and UL 6.

4. ARC: Comply with ANSI C80.5 and UL 6A.
5. IMC: Comply with ANSI C80.6 and UL 1242.
6. PVC-Coated Steel Conduit: PVC-coated [rigid steel conduit] [IMC].
 - a. Comply with NEMA RN 1.
 - b. Coating Thickness: 0.040 inch, minimum.
7. EMT: Comply with ANSI C80.3 and UL 797.
8. FMC: Comply with UL 1; [zinc-coated steel] [or] [aluminum].
9. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.

B. Metal Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB (Electrification Products Division).
 - b. Anamet Electrical, Inc (Anaconda Sealtite).
 - c. Atkore International (AFC Cable Systems).
 - d. Atkore International (Allied Tube & Conduit).
 - e. Atkore International (Calconduit).
 - f. Electri-Flex Company.
 - g. Emerson Electric Co. (Automation Solutions - Appleton - O-Z/Gedney).
 - h. FSR Inc.
 - i. Korkap.
 - j. NEC, Inc.
 - k. NewBasis.
 - l. Opti-Com Manufacturing Network, Inc (OMNI).
 - m. Patriot Aluminum Products, LLC.
 - n. Perma-Cote.
 - o. Plasti-Bond.
 - p. Republic Conduit.
 - q. Southwire Company.
 - r. Topaz Lighting & Electric.
 - s. Western Tube and Conduit Corporation.
 - t. Wheatland Tube Company.
 - u. Zekelman Industries (Picoma).
2. Comply with NEMA FB 1 and UL 514B.
3. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Fittings, General: Listed and labeled for type of conduit, location, and use.
5. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Compression.
6. Expansion Fittings: Steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.

- C. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB (Electrification Products Division).
 2. Eaton (B-line).
 3. Hubbell Incorporated (Wiegmann).
 4. MonoSystems, Inc.
 5. nVent (Hoffman).
 6. Schneider Electric USA (Square D).
- B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 Type 3R unless otherwise indicated, and sized according to NFPA 70.
1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type and/or screw-cover type unless otherwise indicated.
- E. Finish: Manufacturer's standard enamel finish.

2.3 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB (Electrification Products Division).
 2. Adalet.
 3. Eaton (Crouse-Hinds).
 4. Emerson Electric Co. (Automation Solutions - Appleton - EGS).
 5. Emerson Electric Co. (Automation Solutions - Appleton - O-Z/Gedney).
 6. Erickson Electrical Equipment Company.
 7. FSR Inc.
 8. Hubbell Incorporated.
 9. Hubbell Incorporated (Raco Taymac Bell).
 10. Hubbell Incorporated (Wiring Device-Kellems).
 11. Kraloy Fittings.
 12. Legrand North America, LLC (Wiremold).
 13. Milbank Manufacturing Co.
 14. MonoSystems, Inc.
 15. nVent (Hoffman).
 16. Oldcastle Enclosure Solutions.
 17. Plasti-Bond.
 18. Spring City Electrical Manufacturing Company.
 19. Stahlin Non-Metallic Enclosures.
 20. Topaz Lighting & Electric.
- B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.
- E. Boxes: Comply with NEMA OS 2 and UL 514C.
- F. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.
- G. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
- H. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- I. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.
- J. Gangable boxes are allowed.
- K. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1, Type 3R with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
 - 1. Exposed Conduit: IMC.
 - 2. Concealed Conduit, Aboveground: EMT.
 - 3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC, LFNC.
 - 4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- B. Indoors: Apply raceway products as specified below unless otherwise indicated:
 - 1. Exposed, Not Subject to Physical Damage: EMT.
 - 2. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 - 3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 - 4. Exterior Roof Locations: IMC.
 - 5. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 [stainless steel] [nonmetallic] in institutional and commercial kitchens and damp or wet locations.
- C. Minimum Raceway Size: 3/4-inch trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
2. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

3.2 INSTALLATION

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- C. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.
- D. Do not fasten conduits onto the bottom side of a metal deck roof.
- E. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- F. Complete raceway installation before starting conductor installation.
- G. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.
- H. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.
- I. Conceal conduit within finished walls and ceilings unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- J. Support conduit within 12 inches of enclosures to which attached.
- K. Stub-Ups to Above Recessed Ceilings:
 1. Use EMT for raceways.
 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- L. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- M. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
- N. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal

bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

- O. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- P. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- Q. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- R. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- S. Comply with manufacturer's written instructions for solvent welding RNC and fittings.
- T. Expansion-Joint Fittings:
 - 1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC [and EMT] conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
 - 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: [125 deg F] temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: [155 deg F] temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: [125 deg F] temperature change.
 - 3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
 - 4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 - 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- U. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for [recessed and semirecessed luminaires,] equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
 - 1. Use LFMC in damp or wet locations subject to severe physical damage.
 - 2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
- V. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

- W. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
- X. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- Y. Locate boxes so that cover or plate will not span different building finishes.
- Z. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- AA. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

3.3 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.4 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

END OF SECTION

SECTION 260543

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type EPEC raceways and fittings.
2. Type ERMCS raceways, elbows, couplings, and nipples.
3. Type ERMCS raceways, elbows, couplings, and nipples.
4. Type IMC raceways.
5. Type PVC raceways and fittings.
6. Type RTRC-BG raceways and fittings.
7. Fittings for conduit, tubing, and cable.
8. Electrically conductive corrosion-resistant compounds for threaded conduit.
9. Solvent cements.
10. Duct accessories.
11. Handholes and boxes for exterior underground wiring.
12. Manholes for exterior underground wiring.
13. Utility structure accessories.
14. Duct sealing.

B. Related Requirements:

1. Section 260519 "Low-Voltage for Electrical Power Conductors and Cables" specifies nonmetallic underground conduit with conductors (Type NUCC).
2. Section 260553 "Identification for Electrical Systems" specifies underground-line warning tape and concrete cable routing markers (warning planks).

1.2 ALLOWANCES

- ###### A.
- See Section 012100 "Allowances" for description of allowances affecting items specified in this Section.

1.3 ALTERNATES

- ###### A.
- See Section 012300 "Alternates" for description of alternates affecting items specified in this Section.

1.4 DEFINITIONS

- ###### A.
- Duct: A single raceway or multiple raceways, installed singly or as components of a duct bank.
- ###### B.
- Duct Bank: Two or more ducts installed in parallel, direct buried or with additional casing materials such as concrete.
- ###### C.
- Handhole: An underground chamber containing electrical cables, sized such that personnel are not required to enter in order to access the cables.

- D. Manhole: An underground chamber containing electrical cables and equipment, sized to provide access with working space clearances.
- E. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.5 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at project site.
- B. Preinstallation Coordination Meeting(s): For underground ducts and raceways. Conduct meeting(s) as video conference.
 - 1. Attendees: Installers, fabricators, representatives of manufacturers, and administrators for field tests and inspections. Notify Architect, engineer, construction manager, and power company of scheduled meeting dates.

1.6 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. For concrete and steel used in precast concrete manholes and handholes, also include product certificates as required by ASTM C858.
- B. Shop Drawings:
 - 1. Electric Utility Duct Banks and Structures:
 - a. Include plans, elevations, sections, and details, including attachments to other Work.
 - b. Indicate locations of private property boundaries and utility easements.
 - c. Include information required for approval by electric utility and for obtaining public space utility work permits.
 - 2. Precast or Factory-Fabricated Concrete Structures:
 - a. Include plans, elevations, sections, and details, including attachments to other Work.
 - b. Include duct entry provisions, including locations and duct sizes, and methods and materials for waterproofing duct entry locations.
 - c. Include reinforcement details.
 - d. Include frame and cover design and manhole chimneys.
 - e. Include ladder details.
 - f. Include grounding details.
 - g. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, sumps, and other accessories.
 - h. Include joint details.
 - 3. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:
 - a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
 - b. Include duct entry provisions, including locations and duct sizes, and methods and materials for waterproofing duct entry locations.
 - c. Include cover design.

- d. Include grounding details.
- e. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and other accessories.

C. Field quality-control reports.

1.7 INFORMATIONAL SUBMITTALS

A. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

B. Field Reports:

- 1. Factory Test Reports: For handholes and boxes.
- 2. Manufacturer's field reports for field quality-control support.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Spare Parts: Furnish to Owner spare parts necessary for repairing or adding more cables to manholes or handholes that are packaged with protective covering for storage and identified with labels describing contents.

- 1. Cable-Support Stanchions, Arms, and Associated Fasteners: Five percent of quantity of each item installed.
- 2. Insulators: Five percent of quantity of each item installed.

1.9 REGULATORY AGENCY APPROVALS

A. Shop Drawing submittals for electric utility duct banks and structures must be signed and sealed by qualified electrical professional engineer responsible for their preparation. Obtain approval by electric utility prior to submitting for action by Architect.

B. Submit Shop Drawings for electric utility duct banks and structures for action by Architect prior to submitting for approval by electric utility.

PART 2 - PRODUCTS

2.1 TYPE EPEC RACEWAYS AND FITTINGS

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics: UL 651A and UL CCN EAZX.

B. Schedule 40 Electrical HDPE Underground Conduit (EPEC-40):

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Blue Diamond Industries, LLC.
 - b. JM Eagle.
 - c. Petroflex North America.
 - d. Prysmian Cables and Systems; Prysmian Group North America.

- e. Southwire Company, LLC.
 - 2. Dimensional Specifications: Schedule 40.
 - 3. Options:
 - a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
- C. Schedule 80 Electrical HDPE Underground Conduit (EPEC-80):
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Blue Diamond Industries, LLC.
 - b. JM Eagle.
 - c. Petroflex North America.
 - d. Prysmian Cables and Systems; Prysmian Group North America.
 - e. Southwire Company, LLC.
 - 2. Dimensional Specifications: Schedule 80.
 - 3. Options:
 - a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
- D. Type A Electrical HDPE Underground Conduit (EPEC-A):
- 1. Dimensional Specifications: Type A.
 - 2. Options:
 - a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
- E. Type B Electrical HDPE Underground Conduit (EPEC-B):
- 1. Dimensional Specifications: Type B.
 - 2. Options:
 - a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
- 2.2 TYPE ERM-C-SS RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES
- A. Performance Criteria:
- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 - 2. General Characteristics: UL 6A and UL CCN DYWV.
- B. Stainless Steel Electrical Rigid Metal Conduit (ERM-C-SS), Elbows, Couplings, and Nipples:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Allied Tube & Conduit; Atkore International.
 - c. Calconduit; Atkore International.
 - d. Crouse-Hinds; brand of Eaton, Electrical Sector.

- e. Patriot Aluminum Products, LLC.
- 2. Material: Stainless steel.
- 3. Options:
 - a. Minimum Trade Size: designator 21 (trade size 3/4).

2.3 TYPE ERM-S RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics: UL 6 and UL CCN DYIX.

B. Galvanized-Steel Electrical Rigid Metal Conduit (ERM-S-G), Elbows, Couplings, and Nipples:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit; Atkore International.
 - b. Calconduit; Atkore International.
 - c. Crouse-Hinds; brand of Eaton, Electrical Sector.
 - d. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - e. Patriot Aluminum Products, LLC.
 - f. Republic Conduit; Nucor Corporation, Nucor Tubular Products.
 - g. Topaz Lighting & Electric.
 - h. Western Tube; Zekelman Industries.
 - i. Wheatland Tube; Zekelman Industries.
- 2. Exterior Coating: Zinc.
- 3. Options:
 - a. Interior Coating: Zinc with organic top coating.
 - b. Minimum Trade Size: Metric designator 21 (trade size 3/4).

C. PVC-Coated-Steel Electrical Rigid Metal Conduit (ERM-S-PVC), Elbows, Couplings, and Nipples:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Bluesteel Services LLC.
 - c. Calbond; Atkore International.
 - d. KorKap; Robroy Industries.
 - e. Perma-Cote; Robroy Industries.
 - f. Plasti-Bond; Robroy Industries.
- 2. Additional Characteristics:
- 3. Fittings for PVC-Coated Conduit:
 - a. Minimum coating thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

- b. Conduit bodies must be Form 8 with effective seal and positive placement feature to ease and assure proper installation. Certified results confirming seal performance at 15 psig (positive) and 25 inch Hg (vacuum) for 72 hours must be available. Conduit bodies must be supplied with plastic-encapsulated stainless steel cover screws.
 - c. Form 2 inch long or one pipe diameter long, whichever is less, PVC sleeve at openings of female fittings, except unions. Inside sleeve diameter must be matched to outside diameter of metal conduit.
 - d. PVC coating on outside of conduit couplings must be protected from tool damage during installation.
 - e. Female threads on fittings and couplings must be protected by urethane coating.
 - f. Fittings must be from same manufacturer as conduit.
 - g. Beam clamps and U bolts must be formed and sized to fit outside diameter of coated conduit. Plastic-encapsulated nuts must cover exposed portions of threads.
4. Options:
- a. Exterior Coating: PVC complying with NEMA RN 1 and marked ETL Verified PVC-001.
 - b. Interior Coating: Zinc with organic top coating.
 - c. Minimum Trade Size: designator 21 (trade size 3/4).
 - d. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
 - e. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper.

2.4 TYPE IMC RACEWAYS

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics: UL 1242 and UL CCN DYBY.

B. Steel Electrical Intermediate Metal Conduit (IMC):

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Allied Tube & Conduit; Atkore International.
 - c. Calconduit; Atkore International.
 - d. Republic Conduit; Nucor Corporation, Nucor Tubular Products.
 - e. Topaz Lighting & Electric.
 - f. Western Tube; Zekelman Industries.
 - g. Wheatland Tube; Zekelman Industries.
- 2. Options:
 - a. Exterior Coating: Zinc.
 - b. Interior Coating: Zinc with organic top coating.
 - c. Minimum Trade Size: Metric designator 21 (trade size 3/4).

2.5 TYPE PVC RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 2. General Characteristics: UL 651 and UL CCN DZYR.
- B. Schedule 40 Rigid PVC Conduit (PVC-40) and Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Calconduit; Atkore International.
 - c. JM Eagle.
 - d. NAPCO; Westlake Chemical Corp.
 - e. Opti-Com Manufacturing Network, Inc (OMNI).
 - f. Topaz Lighting & Electric.
 2. Dimensional Specifications: Schedule 40.
 3. Options:
 - a. Minimum Trade Size: [Metric designator 16 (trade size 1/2)] [Metric designator 21 (trade size 3/4)].
 - b. Markings: For use with maximum 90 deg C wire.
- C. Schedule 80 Rigid PVC Conduit (PVC-80) and Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Calconduit; Atkore International.
 - c. JM Eagle.
 - d. Opti-Com Manufacturing Network, Inc (OMNI).
 - e. Topaz Lighting & Electric.
 2. Dimensional Specifications: Schedule 80.
 3. Options:
 - a. Minimum Trade Size: Metric designator 21 (trade size 3/4).
 - b. Markings: For use with maximum 90 deg C wire.
- D. Type A Rigid PVC Concrete-Encased Conduit (PVC-A) and Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Southern Pipe, Inc.
 2. Dimensional Specifications: Type A.
 3. Options:
 - a. Minimum Trade Size: [Metric designator 16 (trade size 1/2)] [Metric designator 21 (trade size 3/4)].
- E. Type EB Rigid PVC Concrete-Encased Underground Conduit (PVC-EB) and Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. JM Eagle.
 - b. Southern Pipe, Inc.
2. Dimensional Specifications: Type EB.
3. Options:
 - a. Minimum Trade Size: Metric designator 53 (trade size 2)

2.6 TYPE RTRC-BG RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 2420 and UL CCN DZKT, for Type BG.

B. Low-Halogen, Belowground Reinforced Thermosetting Resin Conduit (RTRC-BG) and Fittings:

1. Options:
 - a. Minimum Trade Size: Metric designator 21 (trade size 3/4).

2.7 FITTINGS FOR CONDUIT, TUBING, AND CABLE

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.

B. Metallic Fittings for Type ERM, Type IMC, Type PVC, Type EPEC, and Type RTRC Raceways:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Appleton; Emerson Electric Co., Automation Solutions.
 - c. Crouse-Hinds; brand of Eaton, Electrical Sector.
 - d. Konkore Fittings; Atkore International.
 - e. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
 - f. Penn Aluminum Conduit & EMT; Penn Aluminum International LLC; Berkshire Hathaway.
 - g. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - h. Southwire Company, LLC.
 - i. Topaz Lighting & Electric.
2. General Characteristics: UL 514B and UL CCN DWTT.
3. Options:
 - a. Material: Steel.
 - b. Coupling Method: Compression coupling.

- c. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
- d. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper.

2.8 ELECTRICALLY CONDUCTIVE CORROSION-RESISTANT COMPOUNDS FOR THREADED CONDUIT

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics: UL Subject 2419 and UL CCN FOIZ.

B. Manufacturers: Subject to compliance with requirements, provide products by the following:

- 1. ABB, Electrification Business.

2.9 SOLVENT CEMENTS

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics: As recommended by conduit manufacturer in accordance with UL 514B and UL CCN DWTT.
- 3. Sustainability Characteristics:

2.10 DUCT ACCESSORIES

A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Allied Tube & Conduit; Atkore International.
 - c. Cantex Inc.
 - d. IPEX USA LLC.
 - e. PenCell Plastics; brand of Hubbell Utility Solutions; Hubbell Incorporated.
 - f. Underground Devices, Inc.

2.11 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics:
 - a. ASTM C858 for design and manufacturing processes.
 - b. SCTE 77.

B. Precast Concrete Handholes and Boxes:

1. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover must form top of enclosure and must have load rating consistent with that of handhole or box.
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Elmhurst-Chicago Stone Co.
 - b. Oldcastle Infrastructure Inc.; CRH Americas.
 - c. Rinker Group, Ltd.
 - d. Riverton Concrete Products.
 - e. Utility Concrete Products, LLC.
 - f. Utility Vault Co.
 - g. Wausau Tile, Inc.
 3. Configuration: Units must be designed for flush burial and have open bottom unless otherwise indicated.
 4. Frame and Cover:
 - a. Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
 - b. Cover Finish: Nonskid finish must have minimum coefficient of friction of 0.50.
 - c. Cover Legend: Molded lettering, "ELECTRIC" or "COMMUNICATIONS".
 5. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
 - a. Extension must provide increased depth of 12 inch
 - b. Slab: Same dimensions as bottom of enclosure and arranged to provide closure.
 6. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at installation location with ground-water level at grade.
 7. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
 - a. Type and size: Match fittings to duct to be terminated.
 - b. Fittings must align with elevations of approaching duct and be located near interior corners of handholes to facilitate racking of cable.
 - c. Provide minimum of one cast end-bell or duct-terminating fitting of each size provided in each wall.
 8. Handholes 12 inch wide by 24 inch long and larger must have inserts for cable racks and pulling-in irons installed before concrete is poured.
- C. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover:
1. Description: Molded of sand, concrete, and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or combination.
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armorcast Products Company; brand of Hubbell Utility Solutions; Hubbell Incorporated.

- b. MacLean Highline.
 - c. NewBasis.
 - d. Oldcastle Infrastructure Inc.; CRH Americas.
 - e. Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated.
 - 3. Configuration: Units must be designed for flush burial and have open bottom unless otherwise indicated.
 - 4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and installed location.
 - a. Cover Finish: Nonskid finish must have minimum coefficient of friction of 0.50.
 - b. Cover Legend: Molded lettering, "ELECTRIC" or "COMMUNICATIONS".
 - 5. Conduit Entrance Provisions: Conduit-terminating fittings must mate with entering ducts for secure, fixed installation in enclosure wall.
 - 6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
 - 7. Duct Entrance Provisions: Duct-terminating fittings must mate with entering duct for secure, fixed installation in enclosure wall.
 - 8. Handholes 12 inch wide by 24 inch long and larger must have factory-installed inserts for cable racks and pulling-in irons.
 - 9. Options:
 - a. Color: Green.
- D. Fiberglass Handholes and Boxes with Polymer Concrete Frame and Cover:
- 1. Description: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armorcast Products Company; brand of Hubbell Utility Solutions; Hubbell Incorporated.
 - b. NewBasis.
 - c. Oldcastle Infrastructure Inc.; CRH Americas.
 - d. Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated.
 - 3. Configuration: Units must be designed for flush burial and have open bottom unless otherwise indicated.
 - 4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
 - a. Cover Finish: Nonskid finish must have minimum coefficient of friction of 0.50.
 - b. Cover Legend: Molded lettering, "ELECTRIC" or "COMMUNICATIONS".
 - 5. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
 - 6. Duct Entrance Provisions: Duct-terminating fittings must mate with entering duct for secure, fixed installation in enclosure wall.
 - 7. Handholes 12 inch wide by 24 inch long and larger must have factory-installed inserts for cable racks and pulling-in irons.
 - 8. Options:

- a. Color: Green.

E. Fiberglass Handholes and Boxes:

1. Description: Molded of fiberglass-reinforced polyester resin, with covers made of reinforced fiberglass.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. MacLean Highline.
 - b. Nordic Fiberglass, Inc.
 - c. Oldcastle Infrastructure Inc.; CRH Americas.
 - d. Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated.
3. Configuration: Units must be designed for flush burial and have open bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
 - a. Cover Finish: Nonskid finish must have minimum coefficient of friction of 0.50.
 - b. Cover Legend: Molded lettering, "ELECTRIC" or "COMMUNICATIONS".
5. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
6. Duct Entrance Provisions: Duct-terminating fittings must mate with entering duct for secure, fixed installation in enclosure wall.
7. Handholes 12 inch wide by 24 inch long and larger must have factory-installed inserts for cable racks and pulling-in irons.
8. Options:
 - a. Color: Green.

F. High-Density Polyethylene (HDPE) Boxes:

1. Description: Injection molded of HDPE or copolymer-polypropylene. Cover must be made of plastic.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Nordic Fiberglass, Inc.
 - b. Oldcastle Infrastructure Inc.; CRH Americas.
 - c. PenCell Plastics; brand of Hubbell Utility Solutions; Hubbell Incorporated.
 - d. Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated.
3. Configuration: Units must be designed for flush burial and have open bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
 - a. Cover Finish: Nonskid finish must have minimum coefficient of friction of 0.50.
 - b. Cover Legend: Molded lettering, "ELECTRIC" or "COMMUNICATIONS".

5. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
6. Duct Entrance Provisions: Duct-terminating fittings must be installed perpendicular to box wall and mate with entering duct for secure, fixed installation in enclosure wall without putting stress on box wall or fitting.
7. Options:
 - a. Color: Green.

2.12 MANHOLES FOR EXTERIOR UNDERGROUND WIRING

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics:
 - a. ASTM C858 for design and manufacturing processes.
 - b. SCTE 77.

B. Precast Concrete Manholes:

1. Description: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carder Concrete Products.
 - b. Elmhurst-Chicago Stone Co.
 - c. Oldcastle Infrastructure Inc.; CRH Americas.
 - d. Rinker Group, Ltd.
 - e. Riverton Concrete Products.
 - f. Utility Concrete Products, LLC.
 - g. Utility Vault Co.
 - h. Wausau Tile, Inc.
3. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus additional 12 inch vertically and horizontally to accommodate alignment variations.
 - a. Center window location.
 - b. Knockout panels must be located no less than 6 inch from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
 - c. Knockout panel opening must have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
 - d. Knockout panel must be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
 - e. Knockout panels must be 1-1/2 to 2 inch thick.
4. Ground Rod Sleeve: Provide 3 inch PVC sleeve in manhole floors 2 inch from wall adjacent to, but not underneath, duct entering structure.

5. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at installation location with ground-water level at grade.
6. Source Quality Control: Test and inspect in accordance with ASTM C1037.

C. Cast-in-Place Concrete Manholes:

1. Description: Underground utility structures, constructed in place, complete with accessories, hardware, and features. Include concrete knockout panels for duct entrance and sleeve for ground rod.
2. Additional Criteria: Comply with Section 033000 "Cast-in-Place Concrete."

2.13 UTILITY STRUCTURE ACCESSORIES

- A. Description: Utility equipment and accessory items used for utility structure access and utility support, listed, and labeled for intended use and application and complying with local utility company requirements.

- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. BILCO Company (The).
2. Campbell Foundry Company.
3. Carder Concrete Products.
4. EJ Group, Inc.
5. Elmhurst-Chicago Stone Co.
6. McKinley Iron Works, Inc.
7. Neenah Foundry Company.
8. NewBasis.
9. Oldcastle Infrastructure Inc.; CRH Americas.
10. Osburn Associates, Inc.
11. Pennsylvania Insert Corporation.
12. Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated.
13. Rinker Group, Ltd.
14. Riverton Concrete Products.
15. Underground Devices, Inc.
16. Utility Concrete Products, LLC.
17. Utility Vault Co.
18. Wausau Tile, Inc.

- C. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.

1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A48/A48M, Class 30B with milled cover-to-frame bearing surfaces; diameter, 29 inch.
 - a. Cover Finish: Nonskid finish must have minimum coefficient of friction of 0.50.
 - b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.
2. Cover Legend: Cast in; selected to suit system.
 - a. Legend:

- 1) "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
 - 2) "ELECTRIC-HV" for duct systems with medium-voltage cables.
3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
- a. Seal joints watertight using preformed plastic or rubber complying with ASTM C990. Install sealing material in accordance with sealant manufacturers' published instructions.
- D. Manhole Sump Frame and Grate: ASTM A48/A48M, Class 30B, gray cast iron.
- E. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2 inch diameter eye, and 1-by-4 inch bolt.
1. Working Load Embedded in 6 inch (150 mm), 4000 psi (27.6 MPa) Concrete: 13,000 lbf minimum tension.
- F. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4 inch diameter eye, rated 2500 lbf minimum tension.
- G. Pulling-in and Lifting Irons in Concrete Floors: 7/8 inch diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; fastened to reinforcing rod; and with exposed triangular opening.
1. Ultimate Yield Strength: 40,000 lbf shear and 60,000 lbf tension.
- H. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2 inch ID by 2-3/4 inch deep, flared to 1-1/4 inch minimum at base.
1. Tested Ultimate Pullout Strength: 12,000 lbf minimum.
- I. Ground Rod Sleeve: 3 inch PVC sleeve in manhole floors 2 inch from wall adjacent to, but not underneath, ducts routed from facility.
- J. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless steel expander clip with 1/2 inch bolt, 5300 lbf rated pullout strength, and minimum 6800 lbf rated shear strength.
- K. Steel Cable Rack Assembly: Hot-dip galvanized, except insulators.
1. Stanchions: T-section or channel with provisions to connect to other sections or channels to form continuous unit; 1-1/2 inch in width by nominal 24 inch long; punched with 14 hook holes on 1-1/2 inch centers for cable-arm attachment.
 2. Arms: 1-1/2 inch wide, lengths ranging from 3 inch with 450 lb minimum capacity to 18 inch with 250 lb minimum capacity. Arms must have slots along full length for cable ties and be arranged for secure mounting in horizontal position at vertical locations on stanchions.
 3. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.
- L. Nonmetallic Cable Rack Assembly: Components fabricated from nonconductive, fiberglass-reinforced polymer.

1. Stanchions: Nominal 36 inch high by 4 inch wide, with provisions to connect to other sections to form continuous unit, with minimum of nine holes for arm attachment.
2. Arms: Arranged for secure, drop-in attachment in horizontal position at locations on cable stanchions, and capable of being locked in position. Arms must be available in lengths ranging from 3 inch with 450 lb minimum capacity to 20 inch with 250 lb minimum capacity. Top of arm must be nominally 4 inch wide, and arm must have slots along full length for cable ties.

M. Fixed Manhole Ladders: Arranged for attachment to wall of manhole. Ladder and mounting brackets and braces must be fabricated from hot-dip galvanized steel.

N. Cover Hooks: Heavy duty, designed for lifts 60 lbf and greater. Two ladders(s) are required.

2.14 DUCT SEALING

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB, Electrification Business.
2. American Polywater Corporation.
3. CommScope, Inc.
4. Gardner Bender.
5. Ideal Industries, Inc.
6. NSi Industries LLC.
7. TE Connectivity Ltd.

B. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F. Compound must be capable of withstanding temperature of 300 deg F without slump and adhering to clean surfaces of plastic ducts, metallic conduit, conduit and duct coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals. Duct sealing compound must be removable without damaging ducts or cables.

C. Inflatable Duct-Sealing System: Wraparound inflatable bladder that seals ducts that are empty or containing conductors against air and water infiltration. System is suitable for use in steel, plastic, or concrete ducts and penetrations.

2.15 SOURCE QUALITY CONTROL

A. Factory Tests for Handholes and Boxes:

1. Testing Administrant: Engage qualified structural testing agency to evaluate handholes and boxes.
 - a. Tests of materials must be performed by independent testing agency.
 - b. Strength tests of complete boxes and covers must be by independent testing agency or manufacturer. Qualified registered professional engineer must certify tests by manufacturer.
2. Factory Tests and Inspections: Perform the following tests and inspections on handholes and boxes, by, or under supervision of, qualified electrical testing laboratory recognized by authorities having jurisdiction, before delivering to site. Affix label with name and date of manufacturer's certification of system compliance.

- a. Precast Concrete Utility Structures: Test and inspect in accordance with ASTM C1037.
 - b. Polymer Concrete and Nonconcrete Handhole and Pull-Box Prototypes: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests must be for specified tier ratings of products supplied. Testing machine pressure gages must have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.
3. Nonconforming Work:
 - a. Equipment that does not pass tests and inspections will be considered defective.
4. Factory Test Reports: Prepare and submit factory test and inspection reports.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Coordinate layout and installation of duct, duct bank, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in field. Notify Architect if there is conflict between areas of excavation and existing structures or archaeological sites to remain.
- B. Coordinate elevations of duct and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to manholes and handholes, and as approved by Architect.
- C. Clear and grub vegetation to be removed, and protect vegetation to remain in accordance with Section 311000 "Site Clearing." Remove and stockpile topsoil for reapplication in accordance with Section 311000 "Site Clearing."

3.2 SELECTION OF UNDERGROUND DUCTS

- A. Duct for Electrical Cables More Than 600 V: PVC-80 concrete encased unless otherwise indicated.
- B. Duct for Electrical Feeders 600 V and Less: PVC-40 concrete encased unless otherwise indicated.
- C. Duct for Electrical Branch Circuits: PVC-40 direct buried unless otherwise indicated.
- D. Underground Ducts Crossing Paved Paths Walks and Driveways: PVC-40 encased in reinforced concrete.
- E. Underground Ducts Crossing Roadways and Railroads: PVC-40, encased in reinforced concrete.
- F. Stub-ups: Concrete encased, IMC.

3.3 SELECTION OF UNDERGROUND ENCLOSURES

A. Handholes and Boxes:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete, AASHTO HB 17, H-20 structural load rating.
2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
3. Units in Sidewalk and Similar Applications with Safety Factor for Nondeliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10 structural load rating.
4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested in accordance with SCTE 77 with 3000 lbf vertical loading.
5. Cover design load must not exceed load rating of handhole or box.

B. Manholes: Precast concrete.

1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating in accordance with AASHTO HB 17.

3.4 EARTHWORK

- A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restoration: Restore area immediately after backfilling is completed.
- C. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 329200 "Turf and Grasses" and Section 329300 "Plants."
- E. Cut and patch existing pavement in path of underground duct, duct bank, and underground structures in accordance with "Cutting and Patching" Article in Section 017300 "Execution."

3.5 INSTALLATION OF DUCTS AND DUCT BANKS

A. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NEMA TCB 2 for installation of underground ducts and duct banks.
2. Consult Architect for resolution of conflicting requirements.

B. Special Techniques:

1. Where indicated on Drawings, install duct, spacers, and accessories into duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.
2. Steel raceway, bends, and fittings in single duct run or duct bank must be of same type.

3. Slope: Pitch duct minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from high point between two manholes to drain in both directions.
4. Expansion and Deflection Fittings: Install expansion and deflection fitting in each duct in area of disturbed earth adjacent to manhole or handhole.
5. Install expansion fitting near center of straight line duct with calculated expansion of more than 3/4 inch.
 - a. Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with minimum radius of 48 inch, both horizontally and vertically, at other locations unless otherwise indicated.
 - b. Field bending must be in accordance with NFPA 70 minimum radii requirements, except bends over 45 degrees must be made with minimum radius of 48 inch. Use only equipment specifically designed for material and size involved. Use PVC heating bender for bending PVC conduit.
 - c. Duct must have maximum of 180 degrees of bends between pull points.
6. Joints: Use solvent-cemented joints in nonmetallic duct and fittings and make watertight in accordance with manufacturer's published instructions. Stagger couplings so those of adjacent duct do not lie in same plane. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with minimum 3 inch of concrete for minimum of 12 inch on each side of coupling.
 - a. Install insulated grounding bushings on steel raceway terminations that are less than 12 inch below grade or floor level and do not terminate in hubs.
7. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing duct will not be subject to environmental temperatures above 104 deg F. Where environmental temperatures are calculated to rise above 104 deg F, and anywhere duct crosses above underground steam line, install insulation blankets listed for direct burial to isolate duct bank from steam line to maintain maximum environmental temperature of 104 deg F.
8. End Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inch o.c. for 5 inch duct, and vary proportionately for other duct sizes.
 - a. Begin change from regular spacing to end-bell spacing 10 ft from end bell, without reducing duct slope and without forming trap in line.
 - b. Grout end bells into structure walls from both sides to provide watertight entrances.
9. Duct Terminators for Entrances to Cast-in-Place Manholes and Concrete Handholes: Use manufactured, cast-in-place duct terminators, with entrances into structure spaced approximately 6 inch o.c. for 4 inch duct, and vary proportionately for other duct sizes.
 - a. Begin change from regular spacing to terminator spacing 10 ft from terminator, without reducing duct line slope and without forming trap in line.
10. Building Wall Penetrations: Make transition from underground duct to steel raceway at least 10 ft outside building wall, without reducing duct line slope away from building and without forming trap in line. Use fittings manufactured for transition to steel raceway type installed. Install steel raceway penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
11. Install manufactured steel raceway elbows for stub-ups at poles unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.

- a. Couple steel elbows to ducts with adapters designed for this purpose, and encase coupling with minimum 3 inch of concrete for minimum of 12 inch on each side of coupling.
12. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15 psig hydrostatic pressure.
13. Pulling Cord: Install 200 lbf test nylon cord in empty ducts.
14. Concrete-Encased Ducts and Duct Bank:
 - a. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified in Section 312000 "Earth Moving" for pipes 6 inch or less in nominal diameter.
 - b. Width: Excavate trench 12 inch wider than duct on each side.
 - c. Depth: Install so top of duct envelope is at least 24 inch below finished grade in areas not subject to deliberate traffic, and at least 30 inch below finished grade in deliberate traffic paths for vehicles unless otherwise indicated. Install so top of duct envelope is below local frost line.
 - d. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
 - e. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than five spacers per 20 ft of duct. Place spacers within 24 inch of duct ends. Stagger spacers approximately 6 inch between tiers. Secure spacers to earth and to duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
 - f. Minimum Space between Ducts: 3 inch between edge of duct and exterior envelope wall, 2 inch between ducts for like services, and 4 inch between power and communications ducts.
 - g. Elbows:
 - 1) Use manufactured duct elbows for stub-ups and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.
 - 2) Use manufactured steel elbows for stub-ups, at building entrances, and at changes of direction in duct run.
 - h. Stub-ups to Outdoor Equipment: Extend concrete-encased steel raceway horizontally minimum of 60 inch from edge of equipment base.
 - 1) Stub-ups must be minimum 4 inch above finished floor and minimum 3 inch from conduit side to edge of slab.
 - i. Stub-ups to Indoor Equipment: Extend concrete-encased steel raceway horizontally minimum of 60 inch from edge of wall. Install insulated grounding bushings on terminations at equipment.
 - 1) Stub-ups must be minimum 4 inch above finished floor and no less than 3 inch from conduit side to edge of slab.
 - j. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.

- k. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
 - l. Concrete Cover: Install minimum of 3 inch of concrete cover between edge of duct to exterior envelope wall, 2 inch between duct of like services, and 4 inch between power and communications ducts.
 - m. Place minimum 6 inch of engineered fill above concrete encasement of duct.
 - n. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
 - 1) Start at one end and finish at other, allowing for expansion and contraction of duct as its temperature changes during and after pour. Use expansion fittings installed in accordance with manufacturer's published instructions, or use other specific measures to prevent expansion-contraction damage.
 - 2) If more than one pour is necessary, terminate each pour in vertical plane and install 3/4 inch reinforcing-rod dowels extending minimum of 18 inch into concrete on both sides of joint near corners of envelope.
 - o. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 033000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.
15. Direct-Buried Duct and Duct Bank:
- a. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inch in nominal diameter.
 - b. Width: Excavate trench 12 inch wider than duct on each side.
 - c. Depth: Install top of duct at least 36 inch below finished grade unless otherwise indicated.
 - d. Set elevation of top of duct bank below frost line.
 - e. Place minimum 3 inch of sand as bed for duct. Place sand to minimum of 6 inch above top level of duct.
 - f. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
 - g. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than five spacers per 20 ft of duct. Place spacers within 24 inch of duct ends. Stagger spacers approximately 6 inch between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
 - h. Install duct with minimum of 3 inch between ducts for like services and 12 inch between power and communications duct.
 - i. Install manufactured steel elbows for stub-ups, at building entrances, and at changes of direction in duct.
 - 1) Couple RNC duct to steel raceway with adapters designed for this purpose, and encase coupling with minimum 3 inch of concrete.
 - 2) Stub-ups to Outdoor Equipment: Extend concrete-encased steel raceway horizontally minimum of 60 inch from edge of base. Install insulated grounding bushings on terminations at equipment.

- a) Stub-ups must be minimum 4 inch above finished base and minimum 3 inch from conduit side to edge of base.
- 3) Stub-ups to Indoor Equipment: Extend concrete-encased steel raceway horizontally on exterior of wall minimum of 60 inch from edge of wall. Install insulated grounding bushings on terminations at equipment.
- 4) Stub-ups through interior floors must be minimum 4 inch above finished floor and no less than 3 inch from conduit side to edge of equipment pad or floor slab.
- j. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inch over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.
- 16. Warning Planks: Bury warning planks approximately 12 inch above direct-buried duct, placing them 36 inch o.c. Align planks along width and along centerline of duct or duct bank. Provide additional plank for each 12 inch increment of duct-bank width over nominal 18 inch. Space additional planks 12 inch apart, horizontally across width of ducts.
- 17. Underground-Line Warning Tape: Bury conducting underground line specified in Section 260553 "Identification for Electrical Systems" no less than 12 inch above concrete-encased duct and duct banks and approximately 12 inch below grade. Align tape parallel to and within 3 inch of centerline of duct bank. Provide additional warning tape for each 12 inch increment of duct-bank width over nominal 18 inch. Space additional tapes 12 inch apart, horizontally across width of ducts.
- 18. Ground ducts and duct banks in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Reference Standards:

- 1. Precast Concrete Handholes: Comply with ASTM C891 unless otherwise indicated.
- 2. Consult Architect for resolution of conflicting requirements.

B. Special Techniques:

- 1. Cast-in-Place Manholes:
 - a. Finish interior surfaces with smooth-troweled finish.
 - b. Knockouts for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inch thick, arranged as indicated.
 - c. Comply with requirements in Section 033000 "Cast-in-Place Concrete" for cast-in-place concrete, formwork, and reinforcement.
- 2. Precast Concrete Handholes and Manholes:

- a. Install units level and plumb and with orientation and depth coordinated with connecting duct to minimize bends and deflections required for proper entrances.
 - b. Unless otherwise indicated, support units on level bed of crushed stone or gravel graded from 1 inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
 - c. Field-cut openings for conduits in accordance with enclosure manufacturer's published instructions. Cut wall of enclosure with tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
3. Elevations:
- a. Manhole Roof: Install with rooftop at least 15 inch below finished grade.
 - b. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch above finished grade.
 - c. Install handholes with bottom below frost line, below grade.
 - d. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
 - e. Where indicated, cast handhole cover frame integrally with handhole structure.
4. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.
- a. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
 - b. Install chimney, constructed of precast concrete collars and rings, and cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight joints and waterproof grouting for frame and chimney.
5. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. After duct has been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.
6. Dampproofing: Apply dampproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Section 071113 "Bituminous Dampproofing." After ducts are connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.
7. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.
8. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
9. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inch for manholes and 2 inch for handholes, for anchor bolts installed in field. Use minimum of two anchors for each cable stanchion.
10. Ground manholes, handholes, and boxes in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.7 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Reference Standards:

1. Consult Architect for resolution of conflicting requirements.

B. Special Techniques:

1. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.
2. Unless otherwise indicated, support units on level bed of crushed stone or gravel, graded from 1/2 inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
3. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.
4. Install handholes and boxes with bottom below frost line, below grade.
5. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
6. Field cut openings for duct in accordance with enclosure manufacturer's published instructions. Cut wall of enclosure with tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
7. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour concrete ring encircling, and in contact with enclosure entry, and with top surface screeded to top of box cover frame. Bottom of ring must rest on compacted earth.
 - a. Concrete: 3000 psi, 28-day strength, complying with Section 033000 "Cast-in-Place Concrete," with troweled finish.
 - b. Dimensions: 10 inch wide by 12 inch deep.
8. Ground handholes and boxes in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.8 FIELD QUALITY CONTROL

A. Field tests and inspections must be witnessed by Architect and authorities having jurisdiction.

B. Tests and Inspections:

1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide minimum 12 inch long mandrel equal to duct size minus 1/4 inch. If obstructions are indicated, remove obstructions and retest.
3. Test manhole[and handhole] grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."

C. Nonconforming Work:

1. Underground ducts, raceways, and structures will be considered defective if they do not pass tests and inspections.
2. Correct deficiencies and retest as specified above to demonstrate compliance.

- D. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.
- E. Manufacturer Services: Engage factory-authorized service representative to support field tests and inspections.
 - 1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at Project site.

3.9 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
- B. Clean internal surfaces of manholes, including sump, and building interiors affected by Work.
 - 1. Sweep floor, removing dirt and debris.
 - 2. Remove foreign material.

END OF SECTION

SECTION 260544

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Round sleeves.
2. Rectangular sleeves.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.
6. Pourable sealants.
7. Foam sealants.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

1. Product Data: For paints and coatings, indicating VOC content.
2. Laboratory Test Reports: For paints and coatings, indicating compliance with requirements for low-emitting materials.

PART 2 - PRODUCTS

2.1 ROUND SLEEVES

A. Steel Wall Sleeves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advance Products & Systems, LLC.
 - b. CCI Piping Systems.
 - c. Flexicraft Industries.
 - d. GPT; an EnPro Industries company.
 - e. Specified Technologies, Inc.
2. General Characteristics: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, plain ends and integral waterstop.

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

B. PVC Pipe Sleeves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CCI Piping Systems.
 - b. GPT; an EnPro Industries company.
 - c. Metraflex Company (The).
2. General Characteristics: ASTM D1785, Schedule 40.

C. Round, Galvanized-Steel, Sheet Metal Sleeves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Benefast.
 - b. Specified Technologies, Inc.
2. General Characteristics: Galvanized-steel sheet; thickness not less than 0.0239 inch; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

2.2 RECTANGULAR SLEEVES**A. Rectangular, Galvanized-Steel, Sheet Metal Sleeves:**

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Abesco Fire LLC.
 - b. Specified Technologies, Inc.
 - c. Wiremold; Legrand North America, LLC.
2. General Characteristics:
 - a. Material: Galvanized sheet steel.
 - b. Minimum Metal Thickness:
 - 1) For sleeve cross-section rectangle perimeter less than 50 inch and with no side larger than 16 inch, thickness must be 0.052 inch.
 - 2) For sleeve cross-section rectangle perimeter not less than 50 inch or with one or more sides larger than 16 inch, thickness must be 0.138 inch.

2.3 SLEEVE-SEAL SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Advance Products & Systems, LLC.
 2. American Polywater Corporation.
 3. BWM Company.
 4. CALPICO, Inc.
 5. Flexicraft Industries.

6. GPT; a division of EnPRO Industries.
7. Metraflex Company (The).
8. Proco Products, Inc.

B. General Characteristics: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable or between raceway and cable.

C. Options:

1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Holdrite; a division of Reliance Worldwide Corporation.

B. General Characteristics: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit must have plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Specified Technologies, Inc.
2. W. R. Meadows, Inc.

B. General Characteristics: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.

1. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Design Mix: 5000 psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

2.6 POURABLE SEALANTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Carlisle Syntec Systems.
2. GAF.
3. Johns Manville; a Berkshire Hathaway company.
4. Specified Technologies, Inc.

B. Performance Criteria:

1. General Characteristics: Single-component, neutral-curing elastomeric sealants of grade indicated below.
 - a. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.

2.7 FOAM SEALANTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Innovative Chemical Products (Building Solutions Group).
 2. The Dow Chemical Company.
- B. Performance Criteria:
 1. General Characteristics: Multicomponent, liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam. Foam expansion must not damage cables or crack penetrated structure.

PART 3 - EXECUTION

3.1 INSTALLATION OF SLEEVES FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Sleeves for Conduits Penetrating Above-Grade, Non-Fire-Rated, Concrete and Masonry-Unit Floors and Walls:
 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall or floor, so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - b. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 3. Size pipe sleeves to provide 1/4 inch annular clear space between sleeve and raceway or cable, unless sleeve-seal system is to be installed or seismic criteria require different clearance.
 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inch above finished floor level. Install sleeves during erection of floors.
- B. Sleeves for Conduits Penetrating Non-Fire-Rated Wall Assemblies:
 1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 2. Seal space outside of sleeves with approved joint compound for wall assemblies.

- C. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- D. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve-seal systems. Size sleeves to allow for 1 inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- E. Underground, Exterior-Wall and Floor Penetrations:
 - 1. Install steel pipe sleeves with integral waterstops. Size sleeves to allow for 1 inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system. Install sleeve during construction of floor or wall.
 - 2. Install steel pipe sleeves. Size sleeves to allow for 1 inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system. Grout sleeve into wall or floor opening.

3.2 INSTALLATION OF RECTANGULAR SLEEVES AND SLEEVE SEALS

- A. Install sleeves in existing walls without compromising structural integrity of walls. Do not cut structural elements without reinforcing the wall to maintain the designed weight bearing and wall stiffness.
- B. Install conduits and cable with no crossings within the sleeve.
- C. Fill opening around conduits and cables with expanding foam without leaving voids.
- D. Provide metal sheet covering at both wall surfaces and finish to match surrounding surfaces. Metal sheet must be same material as sleeve.

3.3 INSTALLATION OF SLEEVE-SEAL SYSTEMS

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

END OF SECTION

SECTION 260553

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Labels.
 - 2. Bands and tubes.
 - 3. Tapes and stencils.
 - 4. Tags.
 - 5. Signs.
 - 6. Cable ties.
 - 7. Miscellaneous identification products.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.
- B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.
- C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.
- D. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with ASME A13.1.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.

- E. Comply with NFPA 70E requirements for arc-flash warning labels.
- F. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- G. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

- A. Raceways and Cables Carrying Circuits at 600 V or Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage and system or service type.
- B. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for ungrounded feeder and branch-circuit conductors.
 - 1. Color shall be factory applied [or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit].
 - 2. Colors for 208/120-V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - 3. Colors for 480/277-V Circuits:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
 - 4. Color for Neutral: White.
 - 5. Color for Equipment Grounds: Green.
 - 6. Colors for Isolated Grounds: Green with two or more yellow stripes.
- C. Raceways and Cables Carrying Circuits at More Than 600 V:
 - 1. Black letters on an orange field.
 - 2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."
- D. Warning Label Colors:
 - 1. Identify system voltage with black letters on an orange background.
- E. Warning labels and signs shall include, but are not limited to, the following legends:
 - 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 - 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

3. <Insert names and wording of warning signs or labels (for example, arc flash, multiple services and voltages, and others>.

F. Equipment Identification Labels:

1. Black letters on a white field.

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Champion America.
 - c. emedco.
 - d. Grafoplast Wire Markers.
 - e. HellermannTyton.
 - f. LEM Products Inc.
 - g. Marking Services, Inc.
 - h. Panduit Corp.
 - i. Seton Identification Products; a Brady Corporation company.

B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. HellermannTyton.
 - c. Marking Services, Inc.
 - d. Panduit Corp.
 - e. Seton Identification Products; a Brady Corporation company.

C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil-thick, vinyl flexible label with acrylic pressure-sensitive adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A'n D Cable Products.
 - b. Brady Corporation.
 - c. Brother International Corporation.
 - d. emedco.
 - e. Grafoplast Wire Markers.
 - f. Ideal Industries, Inc.
 - g. LEM Products Inc.
 - h. Marking Services, Inc.
 - i. Panduit Corp.
 - j. Seton Identification Products; a Brady Corporation company.

2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
 3. Marker for Labels:
 - a. Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - b. Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.
- D. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A'n D Cable Products.
 - b. Brady Corporation.
 - c. Brother International Corporation.
 - d. emedco.
 - e. Grafoplast Wire Markers.
 - f. HellermannTyton.
 - g. Ideal Industries, Inc.
 - h. LEM Products Inc.
 - i. Marking Services, Inc.
 - j. Panduit Corp.
 - k. Seton Identification Products; a Brady Corporation company.
 2. Minimum Nominal Size:
 - a. 1-1/2 by 6 inches for raceway and conductors.
 - b. 3-1/2 by 5 inches for equipment.
 - c. As required by authorities having jurisdiction.

2.4 TAPES AND STENCILS

- A. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. emedco.
 - d. Marking Services, Inc.

PART 3 - EXECUTION (NOT APPLICABLE)

END OF SECTION

SECTION 260573.16

SHORT CIRCUIT STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Computer-based, fault-current study to determine minimum interrupting capacity of circuit protective devices.

B. Related Requirements:

1. Section 260573.16 "Coordination Studies" for overcurrent protective device coordination studies.
2. Section 260573.19 "Arc-Flash Hazard Analysis" for arc-flash studies.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For power system analysis software to be used for studies.

B. Short-Circuit Study Report:

1. Submit the following after approval of system protective devices submittals. Submittals must be in digital form.
 - a. Short-circuit study input data, including completed computer program input data sheets.
 - b. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
 - c. Revised one-line diagram, reflecting field investigation results and results of short-circuit study.

1.3 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.4 QUALITY ASSURANCE

- A. Study must be performed using commercially developed and distributed software designed specifically for power system analysis.
- B. Software algorithms must comply with requirements of standards and guides specified in this Section.

- C. Manual calculations are unacceptable.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CGI CYME.
 - 2. EDSA Micro Corporation.
 - 3. ESA Inc.
 - 4. ETAP - Digital Twin Platform.
 - 5. EasyPower, LLC (formerly ESA Inc.).
 - 6. Power Analytics, Corporation.
 - 7. SKM Systems Analysis, Inc.
- B. Comply with IEEE 399 and IEEE 551.
- C. Analytical features of power systems analysis software program must have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- D. Computer software program must be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

- A. Executive summary of study findings.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram of modeled power system, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Conductor types, sizes, and lengths.
 - 3. Transformer kVA and voltage ratings.
 - 4. Motor and generator designations and kVA ratings.
 - 5. Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
 - 6. Derating factors and environmental conditions.
 - 7. Any revisions to electrical equipment required by study.
- D. Comments and recommendations for system improvements or revisions in written document, separate from one-line diagram.
- E. Protective Device Evaluation:
 - 1. Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment withstand ratings exceed available short-circuit current at equipment installation locations.
 - 2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.

3. For 600 V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

F. Short-Circuit Study Input Data:

1. One-line diagram of system being studied.
2. Power sources available.
3. Manufacturer, model, and interrupting rating of protective devices.
4. Conductors.
5. Transformer data.

G. Short-Circuit Study Output Reports:

1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Equivalent impedance.
2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Calculated asymmetrical fault currents:
 - 1) Based on fault-point X/R ratio.
 - 2) Based on calculated symmetrical value multiplied by 1.6.
 - 3) Based on calculated symmetrical value multiplied by 2.7.
3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. No AC Decrement (NACD) ratio.
 - e. Equivalent impedance.
 - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on symmetrical basis.
 - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on total basis.

PART 3 - EXECUTION

3.1 POWER SYSTEM DATA

- A. Obtain data necessary for conduct of study.
- B. Gather and tabulate required input data to support short-circuit study. Comply with requirements in Section 017839 "Project Record Documents" for recording circuit protective device characteristics. Record data on Record Document copy of one-line diagram. Comply with recommendations in IEEE 551 as to amount of detail that is required to be acquired in field. Field data gathering must be by, or under supervision of, qualified electrical professional engineer. Data include, but are not limited to, the following:

3.2 SHORT-CIRCUIT STUDY

- A. Perform study following general study procedures contained in IEEE 399.
- B. Calculate short-circuit currents according to IEEE 551.
- C. Base study on device characteristics supplied by device manufacturer.
- D. Extent of electrical power system to be studied is indicated on Drawings.
- E. Begin short-circuit current analysis at service, extending down to system overcurrent protective devices as follows:
 - 1. To normal system low-voltage load buses where fault current is 5 kA or less.
 - 2. Exclude equipment supplied by single transformer smaller than 75 kVA.
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. Include ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for fault-current dc decrement to address asymmetrical requirements of interrupting equipment.
- H. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at each equipment indicated on one-line diagram.
 - 1. For grounded systems, provide bolted line-to-ground fault-current study for areas as defined for three-phase bolted fault short-circuit study.
- I. Include in report identification of protective device applied outside its capacity.

END OF SECTION

SECTION 260573.16
COORDINATION STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

B. Related Requirements:

1. Section 260573.13 "Short-Circuit Studies" for fault-current studies.
2. Section 260573.19 "Arc-Flash Hazard Analysis" for arc-flash studies.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For power system analysis software to be used for studies.

B. Coordination Study Report:

1. Submit the following after approval of system protective devices submittals. Submittals [must] [may] be in digital form.
 - a. Coordination-study input data, including completed computer program input data sheets.
 - b. Study and equipment evaluation reports.
 - c. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
 - d. Revised one-line diagram, reflecting field investigation results and results of coordination study.

1.3 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.4 QUALITY ASSURANCE

- A. Studies must be performed using commercially developed and distributed software designed specifically for power system analysis.

- B. Software algorithms must comply with requirements of standards and guides specified in this Section.
- C. Manual calculations are unacceptable.

1.5 REGULATORY AGENCY APPROVALS

- A. Submittals for coordination study requiring approval by authorities having jurisdiction must be signed and sealed by qualified electrical professional engineer responsible for their preparation. [Obtain approval by authorities having jurisdiction prior to submitting for action by Architect.] [Submit for action by Architect prior to submitting for approval by authorities having jurisdiction.]
- B. Submittals for coordination study require action by Architect prior to submitting for approval by authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE

- A. Manufacturers: Subject to compliance with requirements, [provide products by the following] [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 1. CGI CYME.
 - 2. EDSA Micro Corporation.
 - 3. ESA Inc.
 - 4. ETAP - Digital Twin Platform.
 - 5. EasyPower, LLC (formerly ESA Inc.).
 - 6. Power Analytics, Corporation.
 - 7. SKM Systems Analysis, Inc.
- B. Comply with IEEE 242 and IEEE 399.
- C. Analytical features of device coordination study computer software program must have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- D. Computer software program must be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program must report device settings and ratings of overcurrent protective devices and must demonstrate selective coordination by computer-generated, time-current coordination plots.

2.2 COORDINATION STUDY REPORT CONTENTS

- A. Executive summary of study findings.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram of modeled power system, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Conductor types, sizes, and lengths.

3. Transformer kVA and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.
6. Revisions to electrical equipment required by study.
7. Study Input Data: As described in "Power System Data" Article.
 - a. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."

D. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in field. Use manufacturer's data sheets for recording recommended setting of overcurrent protective devices when available.
 - a. Phase and Ground Relays:
 - 1) Device tag.
 - 2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
 - 3) Recommendations on improved relaying systems, if applicable.
 - b. Circuit Breakers:
 - 1) Adjustable pickups and time delays (long time, short time, and ground).
 - 2) Adjustable time-current characteristic.
 - 3) Adjustable instantaneous pickup.
 - 4) Recommendations on improved trip systems, if applicable.
 - c. Fuses: Show current rating, voltage, and class.

E. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for switching schemes and for emergency periods where power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying portion of system covered.
2. Terminate device characteristic curves at point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
3. Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:
 - a. Power utility's overcurrent protective device.
 - b. Medium-voltage equipment overcurrent relays.
 - c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
 - d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
 - e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
 - f. Cables and conductors damage curves.

- g. Ground-fault protective devices.
 - h. Motor-starting characteristics and motor damage points.
 - i. Generator short-circuit decrement curve and generator damage point.
 - j. Largest feeder circuit breaker in each motor-control center and panelboard.
- 5. Maintain selectivity for tripping currents caused by overloads.
- 6. Provide adequate time margins between device characteristics such that selective operation is achieved.
- 7. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance of the Work. Devices to be coordinated are indicated on Drawings.
 - 1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 POWER SYSTEM DATA

- A. Obtain data necessary for conduct of overcurrent protective device study.
 - 1. Verify completeness of data supplied in one-line diagram on Drawings. Call discrepancies to Architect's attention.
 - 2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.
- B. Gather and tabulate required input data to support coordination study. List below is guide. Comply with recommendations in IEEE 551 for amount of detail required to be acquired in field. Field data gathering must be by, or under supervision of, qualified electrical professional engineer. Data include, but are not limited to, the following:

3.3 COORDINATION STUDY

- A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
- B. Comply with IEEE 399 for general study procedures.
- C. Base study on device characteristics supplied by device manufacturer.
- D. Extent of electrical power system to be studied is indicated on Drawings.
- E. Begin analysis at service, extending down to system overcurrent protective devices as follows:
 - 1. To normal system low-voltage load buses where fault current is 5 kA or less.
 - 2. Exclude equipment supplied by single transformer smaller than 75 kVA.

- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
 - G. Transformer Primary Overcurrent Protective Devices:
 - 1. Device must not operate in response to the following:
 - a. Inrush current when first energized.
 - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
 - c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
 - 2. Device settings must protect transformers according to IEEE C57.12.00, for fault currents.
 - H. Motor Protection:
 - 1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
 - 2. Select protection for motors served at voltages more than 600 V according to IEEE 620.
 - I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands maximum short-circuit current for time equivalent to tripping time of primary relay protection or total clearing time of fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.
 - J. Generator Protection: Select protection according to manufacturer's instructions and to IEEE 242.
 - K. Include ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for fault-current dc decrement, to address asymmetrical requirements of interrupting equipment.
 - L. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at each equipment indicated on one-line diagram.
 - 1. For grounded systems, provide bolted line-to-ground fault-current study for areas as defined for three-phase bolted fault short-circuit study.
 - M. Protective Device Evaluation:
 - 1. Evaluate equipment and protective devices and compare to short-circuit ratings.
 - 2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
 - 3. Include in report identification of protective device applied outside its capacity.
- 3.4 LOAD-FLOW AND VOLTAGE-DROP STUDY
- A. Perform load-flow and voltage-drop study to determine steady-state loading profile of system. Analyze power system performance two times as follows:

1. Determine load flow and voltage drop based on full-load currents obtained in "Power System Data" Article.
2. Determine load flow and voltage drop based on 80 percent of design capacity of load buses.
3. Prepare load-flow and voltage-drop analysis and report to show power system components that are overloaded or might become overloaded; show bus voltages that are less than as prescribed by NFPA 70.

3.5 MOTOR-STARTING STUDY

- A. Prepare motor-starting study report, noting light flicker for limits proposed by IEEE 141, and <Insert applicable standards>, and voltage sags so as not to affect operation of other utilization equipment on system supplying motor.

3.6 FIELD ADJUSTING

- A. Adjust relay and protective device settings according to recommended settings provided by coordination study. Field adjustments must be completed by engineering service division of equipment manufacturer under "Startup and Acceptance Testing" contract portion.
- B. Make minor modifications to equipment as required to accomplish compliance with [short-circuit and] protective device coordination studies.
- C. Testing and adjusting must be by qualified [medium-voltage and] low-voltage electrical testing and inspecting agency.
 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for adjustable overcurrent protective devices.

END OF SECTION

SECTION 260573.19

ARC-FLASH HAZARD ANALYSIS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Computer-based, arc-flash study to determine arc-flash hazard distance and incident energy to which personnel could be exposed during work on or near electrical equipment.

B. Related Requirements:

1. Section 260573.13 "Short-Circuit Studies" for fault-current studies.
2. Section 260573.16 "Coordination Studies" for overcurrent protective device coordination studies.

1.2 DEFINITIONS

- ###### A.
- p.u.: Per unit. The reference unit, established as a calculating convenience, for expressing all power system electrical parameters on a common reference base.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For power system analysis software to be used for studies.

B. Study Submittals:

1. Submit the following after approval of system protective devices submittals. Submittals [must] [may] be in digital form:
 - a. Arc-flash study input data, including completed computer program input data sheets.
 - b. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.
 - c. Revised one-line diagram, reflecting field investigation results and results of arc-flash study.

1.4 INFORMATIONAL SUBMITTALS

- ###### A. Product Certificates:
- For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

1.5 QUALITY ASSURANCE

- A. Study must be performed using commercially developed and distributed software designed specifically for power system analysis.
- B. Software algorithms must comply with requirements of standards and guides specified in this Section.
- C. Manual calculations are unacceptable.

1.6 REGULATORY AGENCY APPROVALS

- A. Submittals for arc-flash hazard analysis requiring approval by authorities having jurisdiction must be signed and sealed by qualified electrical professional engineer responsible for their preparation. [Obtain approval by authorities having jurisdiction prior to submitting for action by Architect.] [Submit for action by Architect prior to submitting for approval by authorities having jurisdiction.]
- B. Submittals for arc-flash hazard analysis require action by Architect prior to submitting for approval by authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CGI CYME.
 - 2. EDSA Micro Corporation.
 - 3. ESA Inc.
 - 4. ETAP - Digital Twin Platform.
 - 5. EasyPower, LLC (formerly ESA Inc.).
 - 6. Power Analytics, Corporation.
 - 7. SKM Systems Analysis, Inc.
- B. Comply with IEEE 1584 and NFPA 70E.
- C. Analytical features of device coordination study computer software program must have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

2.2 ARC-FLASH STUDY REPORT CONTENT

- A. Executive summary of study findings.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Conductor types, sizes, and lengths.

3. Transformer kVA and voltage ratings, including derating factors and environmental conditions.
 4. Motor and generator designations and kVA ratings.
 5. Switchgear, switchboard, motor-control center, panelboard designations, and ratings.
- D. Study Input Data: As described in "Power System Data" Article.
- E. Short-Circuit Study Output Data: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."
- F. Protective Device Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."
- G. Arc-Flash Study Output Reports:
1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in report:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. No AC Decrement (NACD) ratio.
 - e. Equivalent impedance.
 - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on symmetrical basis.
 - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on total basis.
- H. Incident Energy and Flash Protection Boundary Calculations:
1. Arcing fault magnitude.
 2. Protective device clearing time.
 3. Duration of arc.
 4. Arc-flash boundary.
 5. Restricted approach boundary.
 6. Limited approach boundary.
 7. Working distance.
 8. Incident energy.
 9. Hazard risk category.
 10. Recommendations for arc-flash energy reduction.
- I. Fault study input data, case descriptions, and fault-current calculations including definition of terms and guide for interpretation of computer printout.
- 2.3 ARC-FLASH WARNING LABELS
- A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce 3.5 by 5 inch (76 by 127 mm) self-adhesive equipment label for each work location included in analysis.
- B. Label must have orange header with wording, "WARNING, ARC-FLASH HAZARD," and must include the following information taken directly from arc-flash hazard analysis:
1. Location designation.
 2. Nominal voltage.

3. Protection boundaries.
 - a. Arc-flash boundary.
 - b. Restricted approach boundary.
 - c. Limited approach boundary.
 4. Arc flash PPE category.
 5. Required minimum arc rating of PPE in Cal/cm squared.
 6. Available incident energy.
 7. Working distance.
 8. Engineering report number, revision number, and issue date.
- C. Labels must be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 ARC-FLASH HAZARD ANALYSIS

- A. Comply with NFPA 70E and its Annex D for hazard analysis study.
- B. Preparatory Studies: Perform [Short-Circuit] [and] [Protective Device Coordination] [study] [studies] prior to starting Arc-Flash Hazard Analysis [or obtain results from another source].
1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 260573.13 "Short-Circuit Studies."
 2. Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article in Section 260573.16 "Coordination Studies."
- C. Calculate maximum and minimum contributions of fault-current size.
1. Maximum calculation must assume maximum contribution from utility and must assume motors to be operating under full-load conditions.
 2. Calculate arc-flash energy at 85 percent of maximum short-circuit current according to IEEE 1584 recommendations.
 3. Calculate arc-flash energy at 38 percent of maximum short-circuit current according to NFPA 70E recommendations.
 4. Calculate arc-flash energy with utility contribution at minimum and assume no motor contribution.
- D. Calculate arc-flash protection boundary and incident energy at locations in electrical distribution system where personnel could perform work on energized parts.
- E. Include medium- and low-voltage equipment locations, except equipment fed from transformers smaller than 75 kVA.
- F. Calculate limited, restricted, and prohibited approach boundaries for each location.

- G. Incident energy calculations must consider accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations must take into account changing current contributions, as sources are interrupted or decremented with time. Fault contribution from motors and generators must be decremented as follows:
 - 1. Fault contribution from induction motors must not be considered beyond three to five cycles.
 - 2. Fault contribution from synchronous motors and generators must be decayed to match actual decrement of each as closely as possible (for example, contributions from permanent magnet generators will typically decay from 10 p.u. to 3 p.u. after 10 cycles).
- H. Arc-flash energy must generally be reported for maximum of line or load side of circuit breaker. However, arc-flash computation must be performed and reported for both line and load side of circuit breaker as follows:
 - 1. When circuit breaker is in separate enclosure.
 - 2. When line terminals of circuit breaker are separate from work location.
- I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.3 POWER SYSTEM DATA

- A. Obtain data necessary for conduct of arc-flash hazard analysis.
 - 1. Verify completeness of data supplied on one-line diagram on Drawings [and under "Preparatory Studies" Paragraph in "Arc-Flash Hazard Analysis" Article]. Call discrepancies to Architect's attention.
 - 2. For new equipment, use characteristics from approved submittals under provisions of action submittals and information submittals for this Project.

3.4 LABELING

- A. Apply [one] arc-flash label on front cover [of each section of equipment] [and on side or rear covers with accessible live parts and hinged doors or removable plates] for each equipment included in study. Base arc-flash label data on highest values calculated at each location.
- B. Each piece of equipment listed below [not fed by single transformer smaller than 75 kVA] must have arc-flash label applied to it:
 - 1. Medium-voltage switchgear.
 - 2. Medium-voltage switches.
 - 3. Medium voltage transformers
 - 4. Low-voltage switchgear
 - 5. Switchboards.
 - 6. Panelboards.
 - 7. Motor-control centers.
 - 8. Low voltage transformers.
 - 9. Safety switches.
 - 10. Control panels.
- C. Note on record Drawings location of equipment where personnel could be exposed to arc-flash hazard during their work.

1. Indicate arc-flash energy.
2. Indicate protection level required.

3.5 APPLICATION OF WARNING LABELS

- A. Install arc-flash warning labels under direct supervision and control of qualified electrical professional engineer.

END OF SECTION

SECTION 260800

ELECTRICAL SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 RELATED SECTIONS

- A. Division 26 – Electrical
- B. Section 019113 – General Commissioning Requirements

1.3 REQUIRMENTS

- A. The Commissioning process requires the participation of Division 26, Electrical, to ensure that all systems fulfill the functional and pre-functional requirements set forth in these construction documents. The general commissioning requirements and coordination are detailed in Section 019113. Division 26, Electrical, shall fulfill commissioning responsibilities assigned to division 26 in accordance with Section 019113.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PRE-FUNCTIONAL CHECKLISTS

- A. Pre-functional checklists assist in the process to document that the equipment and systems are installed properly.
 - a. The contractor will be provided with construction checklists from the CA for completion. The contractor shall complete the checklists as provide the CA with completed copies in accordance with 019113.
 - b. See attached for a sample pre-functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.2 FUNCTIONAL PERFORMANCE TESTING

- A. Intent of functional performance testing is to prove thru functional test procedures proper system operation.
- B. The contractor will be provided with functional performance test procedures to perform while CA witnesses. The contractor shall perform functional tests in accordance with 019113.

- C. See attached for a sample functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.3 PREFUNCTIONAL CHECKLISTS AND FUNCTIONAL PREFORMANCE TESTING

- c. Pre-Functional Checklists and Functional performance testing procedures will be performed on the following system types. (Pre Functional and Functional performance testing requirements are in addition to and do not replace any testing required elsewhere in Division 26 or by applicable codes.) Equipment specifically marked as such below shall be provided with start-up of equipment by factory-authorized service representative.

1. Emergency Generator and associated transfer panels (if applicable)-Provide with factory authorized start-up.
2. Lighting Control Systems
3. Electrical Service and switchgear, transformers, motor control centers, distribution systems, low voltage systems, grounding and bonding systems.

3.4 SAMPLE CHECKLISTS

- A. See Attached.

END OF SECTION

SAMPLE ONLY

Contractor Checklist and Functional Test Procedures

Lighting Systems –Exterior/Interior

1. Participants

Discipline	Name	Company
CxA		
Mechanical		
Controls		
TAB		
Plumbing		
Electrical		
Date Returned to CxA		

Check	Description
<input type="checkbox"/>	The above equipment and systems integral to them are complete and ready for functional testing.
<input type="checkbox"/>	All control system functions for this and all interlocking systems are programmed and operable per contract documents, including final setpoints and schedules with debugging, loop tuning and sensor calibrations completed.
<input type="checkbox"/>	Test and balance completed and approved for the hydronic systems and terminal units connected
<input type="checkbox"/>	All A/E punchlist items for this equipment corrected.
<input type="checkbox"/>	Safeties and operating ranges reviewed.
	Schedules and reviewed
	<ul style="list-style-type: none">This checklist does not take the place of the manufacturer's recommended checkout and startup procedures.Items that do not apply shall be noted with the reasons on this form (N/A = not applicable, BO = by others).Contractors assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off.

3. Installation Checks

Check	Equip Tag➔	Lighting	Comments
Lighting			
Devices installed per manufacturer's instructions and specifications		<input type="checkbox"/>	
Lighting control system installed per plans, specifications and manufacturer's recommendations		<input type="checkbox"/>	
Switches and occupancy sensors installed at correct height and have correct cover / escutcheon plate		<input type="checkbox"/>	

4. Operational Checks

Check	Equip Tag➔	Lighting	Comments
Operational			
Lights are all functioning. No bulbs are burned out		<input type="checkbox"/>	
Lights are not turning on and off frequently causing a disruptions		<input type="checkbox"/>	

5. Functional Testing Record

Lighting Systems

Test#	Mode ID	Test Procedure	Expected Response	Pass Y/N	Note
1	Interior Lighting – Occupancy Sensors	With the room unoccupied and the lights off, enter the space	The occupancy sensor shall see you and the lights shall energize on. While in the space, the lights shall not continually turn off and on.		
2	Interior Lighting – Daylight Dimming	With the room occupied, and the lights on, shine a flashlight on the photocell	The lights should dim as they sense more light in the space.		
3	Exterior Lights On	Engage the time clock/photocell function to simulate a need for the exterior lighting. Cover the Photocell to simulate darkness and override the time clock to simulate a suitable time to be on	All exterior lights should energize on including pole lights, wall packs etc.		
4	Exterior Lights Off	Set the time clock back to normal schedules and remove the covering from the photocell	All exterior lights should turn off including polelights, wall packs, etc.		

SECTION 260943.16

DIGITAL AND WIRELESS NETWORK LIGHTING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

- A. Single space wireless lighting control systems and associated components:
 - 1. Wireless hub(s) for centralized control, monitoring, and system integration.
 - 2. Wireless occupancy/vacancy sensors.
 - 3. Wireless daylight sensors.
 - 4. Wired load control modules with wireless communication inputs.
 - 5. Wired receptacles with wireless communication inputs.
 - 6. Wireless fixture control components factory-installed in luminaires not specified in this section.
 - 7. Wired wall dimmers and switches with wireless communication inputs.
 - 8. Wired wallbox occupancy sensors with wireless communication inputs.
 - 9. Wireless control stations.
 - 10. Power interfaces.
- B. Digital-network lighting control system and associated components:
 - 1. Power panels.
 - 2. LED drivers.
 - 3. Power interfaces.
 - 4. Main units (Lutron Grafik Eye QS).
 - 5. Lighting control modules (Lutron Energi Savr Node).
 - 6. Lighting management hubs.
 - 7. Lighting management system software.
 - 8. Control stations.
 - 9. Low-voltage control interfaces.
 - 10. Wired sensors.
 - 11. Wireless sensors.
 - 12. Accessories.
- C. Software data and analytics dashboard, including server requirements.
- D. Related Requirements:
 - 1. Section 260010 "Supplemental Requirements for Electrical" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.
 - 2. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
 - 3. Preinstallation Meeting: Conduct on-site meeting with lighting control system manufacturer prior to commencing work as part of manufacturer's standard startup services. Manufacturer to review with installer:
 - a. Low voltage wiring requirements.
 - b. Separation of power and low voltage/data wiring.

- c. Wire labeling.
- d. Lighting management hub locations and installation.
- e. Control locations.
- f. Computer jack locations.
- g. Load circuit wiring.
- h. Network wiring requirements.
- i. Connections to other equipment.
- j. Installer responsibilities.
- k. Power panel locations.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Floor plans.
 - 2. Product data:
 - a. Ratings.
 - b. Standard wiring diagrams.
 - c. Configurations
 - d. Dimensions
 - e. Colors
 - f. Service condition requirements
 - g. Installed features
 - 3. Occupancy/Vacancy Sensors: Include detailed basic motion detection coverage range diagrams
 - 4. Wall Dimmers: Include derating information for ganged multiple devices.
 - 5. Manufacturer's Installation Instructions: Include application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
 - 6. Provide schematic system riser diagram indicating component interconnections. Include requirements for interface with other systems.
 - 7. Provide detailed sequence of operations describing system functions.
- C. System Performance-Verification Documentation; Lutron LSC-SPV-DOC: Include as part of the base bid. Additional costs for manufacturer's enhanced documentation detailing start-up performance-verification procedures and functional tests performed along with test results.
- D. Project Record Documents: Record actual installed locations and settings for lighting control system components.
- E. Operation and Maintenance Data: Include detailed information on lighting control system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
- F. Warranty: Submit sample of manufacturer's Warranty or Enhanced Warranty as specified in Part 1 under "WARRANTY". Submit documentation of final executed warranty completed in Owner's name and registered with manufacturer.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample warranty.

1.4 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship within specified warranty period.
- B. Manufacturer's Standard Warranty, With Manufacturer Full-Scope Start-Up; Lutron Standard 2-Year Warranty; Lutron LSC-B2:
 - 1. Manufacturer Lighting Control System Components, Except Lighting Management System Computer, Ballasts/Drivers and Ballast Modules:
 - a. First Two Years:
 - 1) 100 percent replacement parts coverage, 100 percent manufacturer labor coverage to troubleshoot and diagnose a lighting issue.
 - 2) First-available on-site or remote response time.
 - 3) Remote diagnostics for applicable systems.
 - b. Telephone Technical Support: Available 24 hours per day, 7 days per week, excluding manufacturer holidays.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Basis of Design Manufacturer: Lutron Electronics Company, Inc; Vive.
 - 1. Other Acceptable Manufacturers:
 - a. Crestron
 - b. Wattstopper / Legrand
 - c. Leviton
 - d. nLight

2.2 LIGHTING COTNROL GENERAL REQUIREMENTS

- A. Provide products listed, classified, and labeled by Underwriter's Laboratories Inc. (UL) as suitable for the purpose indicated.
- B. Unless specifically indicated to be excluded, provide all required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, programming, etc. as necessary for a complete operating system that provides the control intent indicated.
- C. Design lighting control equipment for 10 year operational life while operating continually at any temperature in an ambient temperature range of 32 degrees F (0 degrees C) to 104 degrees F (40 degrees C) and 90 percent non-condensing relative humidity.
- D. Electrostatic Discharge Tolerance: Design and test equipment to withstand electrostatic discharges without impairment when tested according to IEC 61000-4-2.

- E. Power Failure Recovery: When power is interrupted for periods up to 10 years; and subsequently restored, lights to automatically return to same levels (dimmed setting, full on, or full off) as prior to power interruption.
- F. Wireless Devices
 - 1. Wireless device family includes area or fixture level sensors, area or fixture level load controls for dimming or switching, and load controls that can be mounted in a wallbox, on a junction box, or at the fixture.
 - 2. Wireless devices including sensors, load controls, and wireless remotes or wall stations, can be set up using simple button press programming without needing any other equipment (e.g. central hub, processor, computer, or other smart device).
 - 3. Wireless hub adds the ability to set up the system using any smart device with a web browser (e.g. smartphone, tablet, PC, or laptop).
 - 4. System does not require a factory technician to set up or program the system.
 - 5. Capable of diagnosing system communications.
 - 6. Capable of having addresses automatically assigned to them.
 - 7. Receives signals from other wireless devices and provides feedback to user.
 - 8. Capable of determining which devices have been addressed.
 - 9. RF Range: 60 feet (18 m) line-of-sight or 30 feet (9 m) through typical construction materials between RF transmitting devices and compatible RF receiving devices.
 - 10. Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Limits: Comply with FCC requirements of CFR, Title 47, Part 15, for Class B application.
- G. Wireless Network:
 - 1. RF Frequency: 434 MHz; operate in FCC governed frequency spectrum for periodic operation; continuous transmission spectrum is not permitted.
 - a. Wireless sensors, wireless wall stations and wireless load control devices do not operate in the noisy 2.4 GHz frequency band where high potential for RF interference exists.
 - b. Wireless devices operate in an uncongested frequency band providing reliable operation.
 - c. Fixed network architecture ensures all associated lights and load controls respond in a simultaneous and coordinated fashion from a button press, sensor signal, or command from the wireless hub (i.e. no popcorning).
 - 2. Distributed Architecture: Local room devices communicate directly with each other. If the wireless hub is removed or damaged, local control, sensing, and operation continues to function without interruption.
 - 3. Local room devices communicate directly with each other (and not through a central hub or processor) to ensure:
 - a. Reliability of system performance.
 - b. Fast response time to events in the space (e.g. button presses or sensor signals).
 - c. Independent operation in the event of the wireless hub being removed or damaged.
- H. Device Finishes:
 - 1. Wall Controls: <<As indicated on the drawings; White; Black; Ivory; Light Almond; To be selected by Architect.
 - 2. Standard Colors: Comply with NEMA WD1 where applicable.

3. Color Variation in Same Product Family: Maximum delta E of 1, CIE L*a*b color units.
4. Visible Parts: Exhibit ultraviolet color stability when tested with multiple actinic light sources as defined in ASTM D4674. Provide proof of testing upon request.

- I. Interface with building automation system Lutron System and Network Integration Consultation; LSC-INT-VISIT.

2.3 POWER PANELS

- A. Provide power panels with configurations as indicated on the drawings.

- B. General Requirements:

1. Listed to UL 508 as industrial control equipment.
2. Comply with UL 508A and IEC 60669-2-1 as applicable.
3. Delivered and installed as a listed factory-assembled panel.
4. Field wiring accessible from front of panel without removing dimmer assemblies or other components.
5. Passively cooled via free-convection, unaided by fans or other means.
6. Shipped with each dimmer in mechanical bypass position by means of jumper bar inserted between input and load terminals. Jumpers to carry full rated load current and be reusable at any time. Mechanical bypass device to allow for switching operation of connected load with dimmer removed by means of circuit breaker.
7. Provided with branch circuit protection for each input circuit unless the panel is a dedicated feed-through type panel or otherwise indicated on the drawings.
8. Branch Circuit Breakers:
 - a. Listed to UL 489 as molded case circuit breaker for use on lighting circuits.
 - b. Provided with visual trip indicator.
 - c. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than: indicated on the drawings.
 - d. Thermal-magnetic construction for overload, short-circuit, and over-temperature protection. Use of breakers without thermal protection requires dimmers/relays to have integral thermal protection to prevent failures when overloaded or ambient temperature is above rating of panel.
 - e. Equipped with provision for tag-out/lock-out devices to secure circuit breakers in off position when servicing loads.
 - f. Replaceable without moving or replacing dimmer/relay assemblies or other panel components.
 - g. Listed as switch duty (SWD) so that loads can be switched on and off by breakers.
9. Provide panels with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings as indicated on the drawings.
10. Panel Processor; Lutron Circuit Selector:
 - a. Provide the following capabilities:
 - 1) Operate circuit directly from panel processor for system diagnostics and provide feedback of system operation.
 - 2) Electronically assign each circuit to any zone in lighting control system.
 - 3) Determine normal/emergency function of panel and set emergency lighting levels.

- b. Where indicated on the drawings, panels to provide two control links. Each circuit to be capable of transferring control based on independent programming between architectural control system and theatrical controls utilizing the USITT DMX-512 1990 or ESTA DMX-512A protocol.
- c. React to changes from control within 20 milliseconds.

11. Diagnostics and Service:

- a. Replacing dimmer/relay does not require re-programming of system or processor.
- b. Include diagnostic LEDs for dimmers/relays to verify proper operation and assist in system troubleshooting.
- c. Include tiered control scheme for dealing with component failure that minimizes loss of control for occupant.
 - 1) If lighting control system fails, lights to remain at current level. Panel processor provides local control of lights until system is repaired.
 - 2) If panel processor fails, lights to remain at current level. Circuit breakers can be used to turn lights off or to full light output, allowing non-dim control of lights until panel processor is repaired.
 - 3) If dimmer fails, factory-installed mechanical bypass jumpers to allow each dimmer to be mechanically bypassed. Mechanical bypass device to allow for switching operation of connected load with dimmer removed by means of circuit breaker.

C. Product(s):

1. Specification Grade Dimming Panels:

- a. Product: Lutron GP Series Dimming Panels.
- b. Mounting: Surface.
- c. Dimmers designed and tested specifically to control incandescent/tungsten, magnetic low voltage, electronic low voltage, neon/cold cathode, fluorescent dimming ballasts, and non-dim loads.
- d. Unless otherwise indicated or required, utilize universal 16 A continuous-use listed dimmers.
- e. For loads requiring 0-10V, PWM, or DSI control, utilize compatible multiple load type low voltage dimming modules.
- f. Limit current rise time to minimum 350 microseconds as measured from 10 to 90 percent of load current waveform and minimum 525 microseconds as measured from 0 to 100 percent of load current waveform at 50 percent rated dimmer capacity at a 90 degree conduction angle. Current rise time to be minimum 400 microseconds as measured from 10 to 90 percent of load current waveform and minimum 600 microseconds as measured from 0 to 100 percent of load current waveform at 100 percent rated dimmer capacity at a 90 degree conduction angle.
- g. Load faults only affect the given circuit.

2.4 WIRELESS SENSORS

A. General Requirements:

- 1. Operational life of 10 years without the need to replace batteries when installed per manufacturer's instructions.
- 2. Communicates directly to compatible RF receiving devices through use of a radio frequency communications link.

3. Does not require external power packs, power wiring, or communication wiring.
4. Capable of being placed in test mode to verify correct operation from the face of the unit.

B. Wireless Occupancy/Vacancy Sensors:

1. General Requirements:

- a. Provides a clearly visible method of indication to verify that motion is being detected during testing and that the unit is communicating to compatible RF receiving devices.
- b. Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
- c. Sensing Mechanism: Passive infrared coupled with technology for sensing fine motions; Lutron XCT Technology. Signal processing technology detects fine-motion passive infrared (PIR) signals without the need to change the sensor's sensitivity threshold.
- d. Provide optional, readily accessible, user-adjustable controls for timeout, automatic/manual-on, and sensitivity.
- e. Turns off lighting after reasonable and adjustable time delay once the last person to occupy the space vacates a room or area. Provide adjustable timeout settings of 1, 5, 15, and 30 minutes.
- f. Capable of turning dimmer's lighting load on to an optional locked preset level selectable by the user. Locked preset range to be selectable on the dimmer from 1 percent to 100 percent.
- g. Color: White.
- h. Provide all necessary mounting hardware and instructions for both temporary and permanent mounting.
- i. Provide temporary mounting means for drop ceilings to allow user to check proper performance and relocate as needed before permanently mounting sensor. Temporary mounting method to be design for easy, damage-free removal.
- j. Sensor lens to illuminate during test mode when motion is detected to allow installer to place sensor in ideal location and to verify coverage prior to permanent mounting.
- k. Ceiling-Mounted Sensors:

- 1) Provide surface mounting bracket compatible with drywall, plaster, wood, concrete, and compressed fiber ceilings.
- 2) Provide recessed mounting bracket compatible with drywall and compressed fiber ceilings.

- l. Wall-Mounted Sensors: Provide wall or corner mounting brackets compatible with drywall and plaster walls.

C. Wireless Daylight Sensors:

1. Product: Lutron Radio Powr Savr Series, Model LFR2-DCRB-WH.
2. Open-loop basis for daylight sensor control scheme.
3. Stable output over temperature from 32 degrees F (0 degrees C) to 104 degrees F (40 degrees C).
4. Partially shielded for accurate detection of available daylight to prevent fixture lighting and horizontal light component from skewing sensor detection.
5. Provide linear response from 2 to 150 footcandles.
6. Color: White.
7. Mounting:

- a. Provide surface mounting bracket compatible with drywall, plaster, wood, concrete, and compressed fiber ceilings.
- b. Provide all necessary mounting hardware and instructions for both temporary and permanent mounting.
- c. Provide temporary mounting means for drop ceilings to allow user to check proper performance and relocate as needed before permanently mounting sensor. Temporary mounting method to be design for easy, damage-free removal.

2.5 LOAD CONTROL MODULES

- A. Provide wireless load control modules as indicated or as required to control the loads as indicated.
- B. Junction Box-Mounted Modules:
 1. Plenum rated.
 2. 0-10 V Dimming Modules:
 - a. Product(s):
 - 1) 8 A dimming module with 0-10V control; Lutron PowPak Dimming Module Model RMJS-8T-DV-B.
 - b. Communicates via radio frequency with up to ten compatible occupancy/vacancy sensors, ten wireless control stations, and one daylight sensor.
 - c. Single low voltage dimming module with Class 1 or Class 2 isolated 0-10V output signal conforming to IEC 60929 Annex E.2; source or sink automatically configures.
 - d. Selectable minimum light level.
 - e. Configurable high- and low-end trim.
 - f. Relay: Rated for 0-10 V ballasts, LED drivers, or fixtures that conform with NEMA 410.
3. Phase Selectable Dimming Modules:
 - a. Product(s):
 - 1) Phase selectable dimming module: Lutron Vive Phase Select PowPak Model RMJS-PNE-DV.
 - b. Communicates via radio frequency with up to ten compatible occupancy/vacancy sensors, ten wireless control stations, and one daylight sensor.
 - c. Dimming; Lutron PRO LED+:
 - 1) UL listed for LED control in forward or reverse phase modes. Provide published LED performance testing on both forward and reverse phase dimming.
 - d. Provides leading-edge or trailing-edge dimming; manual configuration.
 - e. Selectable minimum light level.
 - f. Configurable high- and low-end trim.
 - g. Provide cycle-by-cycle compensation for incoming variations, including changes in frequency, harmonics, and line noise; accommodate up to plus/minus two percent change in frequency per second.

- h. Comply with NEMA SSL 7A.
- i. Rated Load: Electronic low voltage (reverse phase, 450 W, 120/277 V), dimmable LED (reverse phase, 450 VA, 120/277 V; forward phase, 200 W, 120 V), incandescent/halogen (450 W, 120/277 V), magnetic low voltage (400 VA/320 W, 120/277 V).

4. Relay Modules:

a. Product(s):

- 1) 16 A relay module, without contact closure output; Lutron PowPak Relay Module Model RMJS-16R-DV-B.
- 2) 16 A relay module, without emergency mode, with contact closure output; Lutron PowPak Relay Module Model RMJS-16RCCO1-DV-B.
- 3) 5 A relay module, without contact closure output; Lutron PowPak Relay Module Model RMJS-5R-DV-B.

b. Communicates via radio frequency with up to ten compatible occupancy/vacancy sensors, ten wireless control stations, and one daylight sensor.

c. Relay:

- 1) Rated Life of Relay: Typical of 1,000,000 cycles at fully rated 16 A for all lighting loads.
- 2) Load switched in manner that prevents arcing at mechanical contacts when power is applied to and removed from load circuits.
- 3) Fully rated output continuous duty for inductive, capacitive, and resistive loads.

d. Contact Closure Output:

- 1) Single contact closure output with normally open and normally closed dry maintained contacts suitable for connection to third party equipment (e.g. building management system, HVAC system, etc.).
- 2) Contact Ratings: Resistive load; 1 A at 0-24 VDC, 0.5 A at 0-24 VAC.
- 3) Controlled by associated occupancy/vacancy sensors and wall controls.

5. Contact Closure Output Modules:

a. Product: Lutron PowPak CCO Module Model RMJS-CCO1-24-B.

b. Communicates via radio frequency with up to ten compatible occupancy/vacancy sensors, ten wireless control stations, and one daylight sensor.

c. Contact Closure Output:

- 1) Single contact closure output with normally open and normally closed dry maintained contacts suitable for connection to third party equipment (e.g. building management system, HVAC system, etc.).
- 2) Contact Ratings: Resistive load; 1 A at 0-24 VDC, 0.5 A at 0-24 VAC.
- 3) Operation affected by associated occupancy/vacancy sensors and wall controls.

C. Fixture Control Modules/Sensors:

1. Fixture Control Modules:

- a. Communicates via radio frequency with up to ten compatible occupancy/vacancy sensors, ten wireless control stations, and one daylight sensor.
- b. Communicates via wired input with one combination occupancy/daylight or vacancy/daylight fixture sensor.
- c. Coordination between Wired and Wireless Sensors:
 - 1) Occupancy/Vacancy Sensing: Wired and wireless sensors work in conjunction (occupancy detected by either sensor turns lights on and vacancy detected by both sensors turns lights off).
 - 2) Daylight Sensing: Wireless sensor takes precedence over wired sensor.
- d. Selectable minimum light level.
- e. Configurable high- and low-end trim.
- f. Plenum rated.
- g. Mounts to fixture or junction box through ½ inch (16 mm) trade size knockout.
- h. 0-10 V Dimming Fixture Control Modules:
 - 1) Product(s):
 - a) 0-10 V dimming fixture control module; Lutron PowPak Wireless Fixture Control for 0-10 V drivers; Model FCJS-010.
 - 2) Supports reporting of energy measurement to wireless hub at accuracy of plus/minus 2 percent or 0.5 W (whichever is higher).
 - 3) Single low voltage dimming module with Class 1 or Class 2 isolated 0-10V output signal conforming to IEC 60929 Annex E.2; source or sink automatically configures.
 - 4) Provides 0-10 V control for up to 3 LED drivers (1 A load at 120-277 V, 6 mA max control current).
 - 5) Rated for switching 0-10 V ballasts, LED drivers, or fixtures that conform with NEMA 410.

2.6 WIRED WALL DIMMERS AND SWITCHES WITH WIRELESS COMMUNICATION INPUTS

A. General Requirements:

- 1. Provide air gap service switch to disconnect power to load for safe lamp replacement, accessible without removing faceplate.
- 2. Operates at the rated capacity across the full ambient temperature range including modified capacities for ganged configurations which require removal of fins.
- 3. Provide radio frequency interference suppression.
- 4. Surge Tolerance: Designed and tested to withstand surges of 6,000 V, 200 amps according to IEEE C62.41.2 without impairment to performance.
- 5. Dimmers: Provide full range, continuously variable control of light intensity.
- 6. Dimmers for Electronic Low Voltage (ELV) Transformers:
 - a. Provide circuitry designed to control the input of electronic (solid-state) low voltage (ELV) transformers. Do not use dimmers that utilize standard phase control.
 - b. Provide resettable overload protection that provides automatic shut-off when dimmer capacity is exceeded. Do not use protection methods that are non-resettable or require device to be removed from outlet box.
 - c. Designed to withstand a short, per UL 1472, between load hot and either neutral or ground without damage to dimmer.

7. Dimmers for Magnetic Low Voltage (MLV) Transformers:
 - a. Provide circuitry designed to control and provide a symmetrical AC waveform to input of magnetic low voltage transformers per UL 1472.
 - b. Magnetic low voltage transformers to operate below rated current or temperature.
 8. Electronic Switches:
 - a. Listed as complying with UL 20, UL 508, and UL 1472.
- B. Preset Smart Wall Dimmers and Switches with Wireless Communication Inputs, Lutron Maestro Wireless Series:
1. Communicates via radio frequency with up to ten compatible occupancy/vacancy sensors, ten wireless control stations, and one daylight sensor.
 2. Dimmer Control: Multi-function tap switch with small, raised rocker for dimmer adjustment.
 - a. Rocker raises/lowers light level, with new level becoming the current preset level.
 - b. Switch single tap raises lights to preset level or fades lights to off.
 - c. Switch double tap raises light to full on level.
 - d. Switch tap and hold slowly fades lights to off over period of 10 seconds.
 - e. LEDs adjacent to tap switch indicate light level when dimmer is on, and function as locator light when dimmer is off.
 3. Switch Control: Switch single tap turns lights on/off.
 4. Dimmer High End Trim:
 - a. Incandescent Dimmers: Minimum of 92 percent of line voltage.
 - b. Dimmers for Electronic Low Voltage (ELV) Transformers: Minimum of 95 percent of line voltage.
 - c. Dimmers for Magnetic Low Voltage Transformers: Minimum of 92 percent of line voltage.
 5. Product(s) - Preset Smart Dimmers with Wireless Communication Inputs:
 - a. Preset Smart Dimmer; Lutron Maestro Wireless Series: Incandescent/halogen (600 W, 120 V), magnetic low voltage (600 VA/450 W, 120 V), dimmable CFL/LED (150 W, 120 V); multi-location capability using companion dimmers (up to nine companion dimmers may be connected); minimum load requirement.
 - 1) Lutron Model MRF2S-6CL; single pole/multi-location; 120 V.
 - b. Preset Smart Dimmer; Lutron Maestro Wireless Series: Electronic low voltage (600 W, 120 V); neutral required; multi-location capability using companion dimmers (up to nine companion dimmers may be connected); minimum load requirement.
 - 1) Lutron Model MRF2S-6ELV-120; single-pole/multi-location; 120 V.
 - c. Preset Smart Dimmer; Lutron Maestro Wireless Series: Incandescent (600 W, 120 V), magnetic low voltage (600 VA/450 W, 120 V); neutral required; multi-location capability using companion dimmers (up to nine companion dimmers may be connected); minimum load requirement.

- 1) Lutron Model MRF2S-6ND-120; or Lutron Model UMRF2S-6ND-120; single-pole/multi-location; 120 V.
- d. Companion Dimmer: Provides multi-location capability for compatible Lutron Maestro Wireless Series dimmers.
 - 1) gloss finish; 120 V.
 - 2) Lutron Model MSC-AD; satin finish; 120 V.
 - 3) Lutron Model MA-R-277V; gloss finish; 277 V.
 - 4) Lutron Model MSC-AD-277V; satin finish; 277 V.
6. Product(s) - Electronic Switches with Wireless Communication Inputs:
 - a. Electronic Switch; Lutron Maestro Wireless Series: 6 A lighting/3 A fan (120 V); neutral required; multi-location capability using companion switches (up to nine companion switches may be connected); minimum load requirement.
 - 1) Lutron Model MRF2S-6ANS; single-pole/multi-location; 120 V.
 - b. Electronic Switch; Lutron Maestro Wireless Series: 8 A lighting/5.8 A fan (120 V); neutral required; multi-location capability using companion switches (up to nine companion switches may be connected); minimum load requirement.
 - 1) Lutron Model MRF2S-8ANS-120; single-pole/multi-location; 120 V.
 - c. Electronic Switch; Lutron Maestro Wireless Series: 8 A lighting/3 A fan (120 V); 8 A lighting (277 V); multi-location capability using companion switches (up to nine companion switches may be connected); minimum load requirement.
 - 1) MRF2S-8S-DV; single-pole/multi-location; 120-277 V.
 - d. Companion Switch: Provides multi-location capability for compatible Lutron Maestro Wireless Series electronic switches.
 - 1) Lutron Model MA-AS; gloss finish; 120 V.
 - 2) Lutron Model MSC-AS; satin finish; 120 V.
 - 3) Lutron Model MA-AS-277V; gloss finish; 277 V.
 - 4) Lutron Model MSC-AS-277V; satin finish; 277 V.

2.7 WIRED WALLBOX OCCUPANCY SENSORS WITH WIRELESS COMMUNICATION INPUTS

- A. 0-10 V Wall Dimmer/Switch Combination Occupancy/Vacancy Sensors with Wireless Communication Inputs; Lutron Maestro Wireless 0-10 Dimmer Sensor/Maestro Wireless Sensor Switch Series:
 1. Communicates via radio frequency with up to ten compatible wireless occupancy/vacancy sensors, ten wireless control stations, and one wireless daylight sensor.
 2. Compatible with sourcing electronic 0-10 V ballasts/drivers, as per IEC 60929 Annex E.2 0-10 V protocol.
 3. Selectable option to enable low light feature (automatic-on when ambient light is below threshold). Ambient light threshold to be selectable as either adaptive utilizing occupant feedback (Lutron Smart Ambient Light Detection) or as fixed (high, medium, low, and minimum presets).

4. Occupancy/Vacancy Sensors:

- a. Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
- b. Sensing Mechanism: Passive infrared coupled with technology for sensing fine motions; Lutron XCT Technology. Signal processing technology detects fine-motion passive infrared (PIR) signals without the need to change the sensor's sensitivity threshold.
- c. Programmable to operate as an occupancy sensor (automatic-on and automatic-off) or a vacancy sensor (manual-on and automatic-off).
- d. Turns off lighting after reasonable and adjustable time delay once the last person to occupy the space vacates a room or area; adjustable timeout settings (1, 5, 15, or 30 minutes).
- e. Adjustable sensitivity (high, medium, low, and minimum presets).
- f. Selectable option to inhibit automatic turn-on of lights after manual-off operation while room is occupied for applications such as presentation viewing in conference rooms and classrooms; when room is vacated, returns to normal automatic-on operation after time delay period.
- g. Selectable walk-through mode to override selected timeout and automatically turn off lights if no motion is detected within 3 minutes after initial occupancy for applications where space may be briefly occupied.

5. Dimmer Features:

- a. Adjustable high/low end trims.
- b. Selectable dimming curve (linear or switched).
- c. Selectable fade on/fade off times (15, 5, 2.5, or 0.75 sec).
- d. Adjustable auto-on light level (fully adjustable from one to 100 percent).

6. Dimmer Control: Multi-function tap switch with small, raised rocker for dimmer adjustment.

- a. Rocker raises/lowers light level, with new level becoming the current preset level.
- b. Switch single tap raises lights to preset level or fades lights to off.
- c. Switch double tap raises light to full on level.

7. Switch Control: Switch single tap turns lights on/off.

a. Product(s):

- 1) Passive Infrared 0-10 V Wall Dimmer Occupancy/Vacancy Sensor; Lutron Maestro Wireless 0-10 V Dimmer Sensor/Maestro Wireless Sensor Switch Series: 0-10 V control for 0-10 V LED drivers (8 A load at 120-277 V, 50 mA max control current); coverage of 900 square feet (81 sq m) with mounting height of 4 feet (1.2 m); 180 degree field of view; multi-location capability using Pico wireless control stations with wallbox mounting adapter.

- a) Sensor dimmer; occupancy/vacancy; Lutron Model MRF2S-8SD010.
- b) Sensor switch; occupancy/vacancy; Lutron Model MRF2S-8SS.

2.8 WIRELESS CONTROL STATIONS

A. Product(s):

1. 2-Button Control; Lutron Pico Wireless Control Model PJ2-2B.
 2. 2-Button with Raise/Lower Control; Lutron Pico Wireless Control Model PJ2-2BRL.
 3. 3-Button Control; Lutron Pico Wireless Control Model PJ2-3B.
 4. 3-Button with Raise/Lower Control; Lutron Pico Wireless Control Model PJ2-3BRL.
 5. 4-Button; Lutron Pico Wireless Control Model PJ2-4B.
 - a. Button Marking: Zone controls (light); Scene keypads (light); 2-group controllers (lights); 4-group toggle: As indicated on drawings.
 6. Single Pedestal; Lutron Pico Pedestal Model L-PED1.
 7. Double Pedestal; Lutron Pico Pedestal Model L-PED2.
 8. Triple Pedestal; Lutron Pico Pedestal Model L-PED3.
 9. Quadruple Pedestal; Lutron Pico Pedestal Model L-PED4.
 10. Screw Mounting Kit; Lutron Model PICO-SM-KIT.
 11. Wallbox Adapter; Lutron Model PICO-WBX-ADAPT.
- B. Communicates directly to compatible RF receiving devices through use of a radio frequency communications link.
- C. Does not require external power packs, power or communication wiring.
- D. Allows for easy reprogramming without replacing unit.
- E. Button Programming:
1. Single action.
 2. Toggle action.
- F. Includes LED to indicate button press or programming mode status.
- G. Mounting:
1. Capable of being mounted with a table stand or directly to a wall under a faceplate.
 2. Faceplates: Provide concealed mounting hardware.
- H. Power: Battery-operated with minimum ten-year battery life (3-year battery life for night light models).
- I. Finish: As indicated on drawings and to be selected by Architect; or Engineer.

2.9 WIRED CONTROL STATIONS

- A. Provide control stations with configuration as indicated or as required to control the loads as indicated.
1. Wired Control Stations:
 - a. General Requirements:
 - b. Power: Class 2 (low voltage).
 - c. UL listed.
 - d. Provide faceplates with concealed mounting hardware.
 - e. Borders, logos, and graduations to use laser engraving or silk-screened graphic process that chemically bonds graphics to faceplate, resistant to removal by scratching and cleaning.

- f. Finish: to be selected by Architect.
2. Multi-Scene Wired Control:
- a. General Requirements:
 - 1) Allows control of any devices part of the lighting control system.
 - 2) Allows for easy reprogramming without replacing unit.
 - 3) Replacement of units does not require reprogramming.
 - 4) Communications: Utilize RS485 wiring for low-voltage communication.
 - 5) Engrave keypads with button, zone, and scene descriptions as indicated on the drawings or to be selected by Architect.
 - 6) Software Configuration:
 - a) Customizable control station device button functionality:
 - b) Buttons can be programmed to perform single defined action.
 - c) Buttons can be programmed to perform defined action on press and defined action on release.
 - d) Buttons can be programmed using conditional logic off of a state variable such as time of day or partition status.
 - e) Buttons can be programmed to perform automatic sequence of defined actions.
 - f) Capable of deactivating select keypads to prevent accidental changes to light levels.
 - g) Buttons can be programmed for raise/lower of defined loads.
 - h) Buttons can be programmed to toggle defined set of loads on/off.
 - 7) Status LEDs:
 - a) Upon button press, LEDs to immediately illuminate.
 - b) LEDs to reflect the true system status. LEDs to remain illuminated if the button press was properly processed or LEDs to turn off if the button press was not processed.
 - c) Support logic that defines when LED is illuminated:
 - d) Scene logic (logic is true when all zones are at defined levels).
 - e) Room logic (logic is true when at least one zone is on).
 - f) Pathway logic (logic is true when at least one zone is on).
 - g) Last scene (logic is true when spaces are in defined scenes).
 - b. Wired Keypads; Lutron seeTouch QS Keypads:
 - 1) Style: Architectural Architectural Insert Style; Designer Style.
 - 2) Communications: Utilize RS485 wiring for low-voltage communications link.
 - 3) Mounting: Wallbox or low-voltage mounting bracket; provide wall plates with concealed mounting hardware.
 - 4) Button/Engraving Backlighting:
 - a) Utilize backlighting for buttons and associated engraving to provide readability under all light conditions.
 - b) Backlight intensity adjustable via programming software.
 - 5) Design keypads to allow field-customization of button color, configuration, and engraving using field-changeable replacement kits.

- 6) Contact Closure Interface: Provide two contact closure inputs on back of unit which provide independent functions from front buttons; accepts both momentary and maintained contact closures.
- 7) Terminal block inputs to be over-voltage and miswire-protected against wire reversals and shorts.

2.10 LOW-VOLTAGE CONTROL INTERFACES

- A. Provide low-voltage control interfaces as indicated or as required to control the loads as indicated.
- B. UL listed.
- C. Contact Closure Interface:
 1. Product: Lutron Model QSE-IO.
 2. Connects to lighting management hub via RS485.
 3. The contact closure input device to accept both momentary and maintained contact closures.
 4. The contact closure output device can be configured for maintained or pulsed outputs.
 5. Contact closure can be programmed using conditional logic off of a state variable such as time of day or partition status.
- D. RS232 and Ethernet Interface:
 1. Product: Lutron Model QSE-CI-NWK-E.
 2. Connects to lighting management hub via RS485.
 3. Provide ability to communicate via Ethernet or RS232 to audiovisual equipment, touchscreens, etc.
 4. Provide control of:
 - a. Light scene selections.
 - b. Fine-tuning of light scene levels with raise/lower.
 - c. Simulate system wall station button presses and releases.
 5. Provide status monitoring of:
 - a. Light scene status.
 - b. Wall station button presses and releases.
 - c. Wall station LEDs.
 6. Provide ability to send custom output strings.
- E. Sensor Modules:
 1. Products:
 - a. Sensor module with both wired and wireless inputs; Lutron Model QSM2-4W-C.
 2. Power Interfaces
- F. Provide power interfaces as indicated or as required to control the loads as indicated.
- G. General Requirements:

1. Provide power interfaces as indicated or as required to control the loads as indicated.
2. General Requirements:
3. Provide power interfaces as indicated or as required to control the loads as indicated.
4. General Requirements:

H. Product(s):

1. Phase-Adaptive Power Module; Lutron PHPM-PA: Provides interface for phase control input to provide full 16 A circuit output of forward/reverse phase control for compatible loads.

2.11 WIRELESS LIGHTING MANGEMENT HUBS

A. Product(s):

1. Wireless hub with BACnet; Lutron Vive Premium Hub.
 - a. Flush-mount wireless hub; Model HJS-2-FM; supports up to 700 total paired devices.
 - b. Surface-mount wireless hub; Model HJS-2-SM; supports up to 700 total paired devices.

B. Integrated multicolor LED provides feedback on what mode the hub is in for simple identification and diagnosis.

C. Integrated processor and web server allows hub to set up and operate the system without any external connections to outside processors, servers, or the internet.

D. Utilizes Ethernet connection for:

1. Networking up to 64 hubs together to create a larger system.
2. Integration with Building Management System (BMS) via native BACnet; does not require interface (Lutron Vive Premium wireless hub with BACnet only).
3. Remote connectivity capabilities, including maintaining system date/time and receiving periodic firmware updates (requires internet connection).

E. A single hub or network of hubs can operate on either a dedicated lighting control only network or can be integrated with an existing building network as a VLAN.

F. Communicates directly to compatible Lutron Vive RF devices through use Lutron Clear Connect radio frequency communications link; does not require communication wiring; RF range of 71 feet (23 m) through walls to cover an area of 15836 square feet (1471 sq m) (device and hub must be on the same floor).

G. Communicates directly to mobile device (smartphone or tablet) or computer using built-in Wi-Fi, 2.4 GHz 802.11b/g; wireless range of 71 feet (23 m) through walls (device and hub must be on the same floor).

1. Does not require external Wi-Fi router for connecting to the hub.

H. Allows for system setup, control, and monitoring from mobile device or computer using Vive web-based software:

1. Supports paired devices up to maximum number indicated including compatible wireless sensors, wireless control stations, and wireless load devices.
2. Allows for timeclock scheduling of events, both time of day and astronomic (sunrise and sunset).
 - a. Timeclock is integrated into the unit and does not require a constant internet connection.
 - b. Retains time and programming information after a power loss.
 - c. 365-day schedulable timeclock allows for:
 - 1) Scheduling of events years in advance.
 - 2) Setting of recurring events with exceptions on holidays.
 - d. Time clock events can be scheduled to:
 - 1) Send lights to a desired level and select the fade rate desired to reach that level.
 - 2) Adjust level lights go to when occupied.
 - 3) Adjust level lights go to when unoccupied.
 - 4) Enable/disable occupancy.
 - 5) Control individual devices, areas, or groups of areas. When connected to Vive Vue server, only areas or groups of areas can be controlled with timeclock events.
3. Daylighting:
 - a. Daylighting can be enabled/disabled. Can be used to override the control currently taking place in the space.
 - a) Daylight set point can be adjusted with the software to increase or decrease the electric light level in the room based on the same amount of natural light.
4. Allows for control, monitoring, and adjustment from anywhere in the world (Lutron Vive wireless hub internet connection required).
5. Uses RF signal strength detection to find nearby devices for quick association and programming without having to climb ladders.
 - a. Association and setup do not require a factory technician to perform.
6. System using Lutron Vive wireless hub(s) can operate with or without connection to the internet.
7. Supports energy reporting.
 - a. Reports measured energy data for PowPak fixture control modules at accuracy of plus/minus 2 percent or 0.5 W (whichever is higher).
 - b. Reports calculated energy data for PowPak junction box mounted modules at accuracy of 10 percent.
 - c. Reports measured energy for DFCSJ Series wireless fixture control dongle when paired with driver that supports measured power (measurement accuracy defined by driver specification) or reports calculated power if driver does not have measurement capabilities.
8. Supports automatic demand response for load shedding via:

- a. Local contact closure without the need for separate interface.
 - b. OpenADR® 2.0b compliant utility command.
 - c. BACnet (Lutron Vive Premium wireless hub with BACnet only).
- 9. Support automatic generation of alerts in Lutron Vive web-based application for designated events/triggers, including:
 - a. Low-battery condition in battery-operated sensors and controls; alert cleared when battery is replaced.
 - b. Missing device (e.g., control or sensor); alert cleared when device is detected by system.
- 10. Wireless hub can be firmware upgraded to provide new software features and system updates.
 - a. Firmware update can be done either locally using a wired Ethernet connection or Wi-Fi connection, or remotely if the wireless hub is connected to the internet.
- I. Lutron Vive Web-Based Application:
 - 1. Accessibility and Platform Support:
 - a. Web-based; runs on most HTML5 compatible browsers (including Safari and Chrome).
 - b. Supports multiple platforms and devices; runs from a tablet, desktop, laptop, or smartphone.
 - c. User interface supports multi-touch gestures such as pinch to zoom, drag to pan, etc.
 - d. Utilizes HTTPS (industry-standard certificate-based encryption and authentication for security).
 - e. Multi-level Password Protected Access: Individual password protection on both the integrated Wi-Fi network and web-based software.
 - f. WPA2 security for Wi-Fi communication with wireless hub.
 - 2. System Navigation and Status Reporting:
 - a. Area Tree View: Easy navigation by area name to view status and make programming adjustments through the software.
 - b. Area and device names can be changed in real time.
 - 3. Setup app available for iOS and Android that allows for:
 - a. Job registration to extend product warranty.
 - b. Management of setup for multiple projects in different locations.
 - c. Creation of handoff documents that are sent directly to a facility manager via email once setup is complete.
 - d. Backup of Vive wireless hub database to Lutron cloud for hub replacement.
 - e. Access to native help and instructions to assist user with Vive system setup.
- J. BACnet Integration (Lutron Vive Premium wireless hub with BACnet only):
 - 1. Provide ability to communicate by means of native BACnet IP communication (does not require interface) to lighting control system from a user-supplied 10BASE-T or 100BASE-T Ethernet network.

2. Requires only one network connection per hub.
3. BACnet Integrator Capabilities:
 - a. The BACnet integrator can command:
 - 1) Area light output.
 - 2) Area load shed level.
 - 3) Area load shed enable/disable.
 - 4) Enable/Disable:
 - a) Area occupancy sensors.
 - b) Area daylighting.
 - 5) Daylighting level.
 - 6) Area occupied and unoccupied level
 - 7) Occupancy sensor timeouts (for fixture sensors).
 - b. The BACnet integrator can monitor:
 - 1) Area on/off status.
 - 2) Area occupancy status.
 - 3) Area load shed status.
 - 4) Area instantaneous energy usage and maximum potential power usage.
 - 5) Enable/Disable:
 - a) Area occupancy sensors.
 - b) Daylighting.
 - c) Timeclocks.
 - 6) Daylighting level.
 - 7) Light levels from photo sensors.
 - 8) Area occupied and unoccupied level.
 - 9) Occupancy sensor timeouts.

K. API Integration:

1. Support communication, without requiring interface, between lighting control system and third-party systems via RESTful API.
2. Requires one network connection per wireless hub.
3. API Integration Capabilities:
 - a. Control all zones or subset of zones.
 - 1) Set zones in designated area to specific level.
 - 2) Raise/lower dimmable lights in designated area.
 - b. Control individual zones.
 - c. Subscribe to and Monitor:
 - 1) Area status changes (e.g., occupancy, light level, and instantaneous power).
 - 2) Individual zone changes in light level.
 - 3) Alerts (e.g., missing device and low battery).

L. Scenes:

1. Support programmable scenes to control individual devices, areas, or groups of areas on demand.
2. Scenes may be activated via:
 - a. Contact closure input.
 - b. API integration.
 - c. Manual activation in app.

M. Contact Closure Interface: Provide two contact closure inputs; accepts both momentary and maintained contact closures that can be used for automatic demand response.

N. Rated for use in air-handling spaces as defined in UL 2043.

O. Meets CAL TITLE 24 P6 requirements.

P. Provide Ethernet switch(es) as required for inter-hub network wiring per manufacturer's instructions; do not exceed manufacturer's required maximum wiring segment lengths.

2.12 DIGITAL NETWORKED SYSTEM LIGHTING MANAGEMENT HUBS

A. Product : Lutron Quantum Light Management Hub.

B. Provided in a pre-assembled NEMA listed enclosure with terminal blocks listed for field wiring.

C. Connects to controls and power panels via RS485.

D. Enables light management software to control and monitor compatible dimming ballasts and ballast modules, power panels, power modules, and window treatments.

1. Utilizes Ethernet connectivity to light management computer utilizing one of the following methods:
 - a. Dedicated network.
 - b. Dedicated VLAN.
 - c. Shared network with Building Management System (BMS).
 - d. Corporate network where managed switches are configured to allow multicasting and use of IGMP.

E. Integrates control station devices, power panels, shades, preset lighting controls, and external inputs into a single customizable lighting control system with:

1. Multiple Failsafe Mechanisms:
 - a. Power failure detection via emergency lighting interface.
 - b. Protection: Lights go to full on if ballast wires are shorted.
 - c. Distributed architecture provides fault containment. Single hub failure or loss of power does not compromise lights and shades connected to other lighting management hubs.
2. Manual overrides.
3. Automatic control.
4. Central computer control and monitoring.
5. Integration with BMS via BACnet.

- F. Furnished with astronomical time clock.
- G. Furnished with solar clock to track the position of the sun to control the shades to limit penetration of direct sunlight.
- H. Maintains a backup of the programming in a non-volatile memory capable of lasting more than ten years without power.
- I. BACnet Integration License:
 - 1. Provide ability to communicate by means of native BACnet IP communication (does not require interface) to lighting control system from a user-supplied 10BASE-T or 100BASE-T Ethernet network.
 - 2. Requires only one network connection per system.
 - 3. Lighting control system to be BACnet Test Laboratory (BTL) listed.
 - 4. Basic BACnet integration license:
 - a. The BACnet integrator can command:
 - 1) Area light output.
 - 2) Area enable or disable after hours mode.
 - 3) Area load shed level.
 - 4) Area load shed enable/disable.
 - 5) Enable/Disable:
 - a) Automated solar adaptive shade control.
 - b) Brightness override mode for automated shade control.
 - c) Area occupancy sensors.
 - d) Area daylighting.
 - 6) Daylighting level.
 - 7) Area occupied and unoccupied level
 - 8) Occupancy sensor timeouts.
 - b. The BACnet integrator can monitor:
 - 1) Area on/off status.
 - 2) Area occupancy status.
 - 3) Area fault.
 - a) Lamp failures.
 - b) Control devices not responding.
 - 4) Area load shed status.
 - 5) Area instantaneous energy usage and maximum potential power usage.
 - 6) Energy savings broken out by strategy (occupancy, timeclock, daylighting, personal control, tuning, load shed) down to the individual area.
 - 7) Area shade group presets and levels.
 - 8) Cloudy day and shadow sensor status.
 - 9) Light levels from window mounted sensors.
 - 10) Enable/Disable:
 - a) Area occupancy sensors.
 - b) Daylighting.

c) Timeclocks.

- 11) Daylighting level.
- 12) Light levels from photo sensors or Radio Window sensors.
- 13) Area occupied and unoccupied level.
- 14) Occupancy sensor timeouts.

c. Shade assignment and grouping to be discoverable with third party building management software.

J. Integration with other devices over Ethernet via Telnet using the Lutron Integration Protocol.

K. Control other devices over Ethernet via TCP or Telnet by sending device specific strings.

2.13 WIRELESS SYSTEM SOFTWARE DATA AND ANALYTICS DASHBOARD

A. Control and Monitor Software:

- 1. Product: Lutron Vive Vue.
- 2. General Requirements:

- a. Web-based; runs on most HTML5 compatible browsers (including Internet Explorer, Chrome, and Safari).
- b. Supports multiple platforms and devices; runs from a tablet, desktop, laptop, or smartphone; optimized for displays of 1024 by 768 pixels or higher.
- c. User interface supports multi-touch gestures such as pinch to zoom, drag to pan, etc.
- d. Utilizes HTTPS (industry-standard certificate-based encryption and authentication for security).
- e. All functionality listed below must be available via a single application.

3. System Navigation and Status Reporting:

- a. Performed using graphical floor plan view or a generic system layout.
- b. Graphical Floor Plan View: Utilizes customized CAD based drawing of the building. Pan and zoom feature allow for easy navigation; dynamically adjusts the details presented based on zoom level.

4. Control of Lights:

- a. Control and monitor zone/area lights.
 - 1) Area lights can be monitored for on/off status from a graphical floor plan or generic system layout.
 - 2) All lights in an area can be turned on/off (dimmable lights can also be dimmed up/down from current level).

5. Occupancy:

- a. Area occupancy can be monitored.
 - 1) Can be monitored graphically if a graphical floor plan has been created.
 - 2) Can be monitored historically in space utilization reports.

- b. Scheduled events can be created to change occupancy parameters as described under "Scheduling" below.
- 6. Load Shedding: View current load shed status (active/inactive) for each Vive wireless hub and enable/disable load shed for the entire building/system.
- 7. Scheduling: Schedule time of day and astronomic time clock events to automate functions.
 - a. Scheduled events can control the following:
 - 1) Area light levels for all dimmable lights in an area.
 - 2) On/off status of all switched lights and contact-closure outputs in an area.
 - 3) On/off status of all switched receptacles in an area.
 - b. Scheduled events can be created to change the following occupancy parameters:
 - 1) Enable/disable sensors.
 - 2) Change occupancy mode (auto-on/auto-off versus manual-on/auto-off).
 - 3) Adjust occupied and/or unoccupied level.
 - 4) For compatible individual fixture sensors, sensor timeout can be adjusted.
 - c. Easily monitor and adjust scheduled events using a weekly calendar view.
- 8. Reporting: Provide reporting capability that allows the building manager to gather real-time and historical information about the system as follows:
 - a. Energy Reports: Show a comparison of cumulative energy used over a period of time for one or more areas.
 - b. Power Reports: Show power usage trend over a period of time for one or more areas.
 - c. Space Utilization/Occupancy Reports: Show historical occupancy over a period of time for one or more areas using a graphical floor plan, generic system layout, and graphs and charts.
- 9. Administration:
 - a. Users: Allows new user accounts to be created and existing user accounts to be edited.
 - 1) Supports Active Directory (LDAP) tying user accounts to network accounts.
 - b. Area and feature access can be restricted based on login credentials.
 - c. Supports up to 20 concurrent users and 10,000 user accounts.
- 10. Devices/Settings Adjustment:
 - a. Users with appropriate permissions can navigate to the wireless hub setup screens in order to view and/or adjust specific settings for areas or devices (including load shed settings, daylighting settings, device associations and programming, occupancy settings, high-end/low-end trim settings, etc).
- 11. Control and Monitor for Multiple Quantum Vue and/or Vive Vue Systems; Lutron Enterprise Vue:

- a. Allows user to view aggregate data from multiple connected Quantum Vue and/or Vive Vue systems spanning multiple buildings through a single user account:
 - 1) Space utilization/occupancy.
 - 2) Energy usage/savings.
- b. Allows user to view details and adjust settings for any connected Quantum Vue or Vive Vue system; supports system navigation through campuses and buildings using graphical floor plans.

2.14 DIGITAL NETWORK LIGHTING MANAGEMENT SYSTEM SOFTWARE

- A. Provide system software license and hardware that is designed, tested, manufactured, and warranted by a single manufacturer.
- B. Configuration Setup Software:
 - 1. Product: Lutron Q-Design.
 - 2. Suitable to make system programming and configuration changes using a graphical floor plan view or a generic system layout.
 - 3. Windows-based, capable of running on either central server or a remote client over TCP/IP connection.
 - 4. Publish Graphical Floor Plan: Allows the user to publish new graphical floor plan files, allowing users to monitor the status of lights, occupancy of areas, and daylighting status.
 - 5. Back-Up Project Database: Allows the user to back up the project database that holds all the configuration information for the system, including keypad programming, area scenes, daylighting, occupancy programming, emergency levels, night lights, and time clock.
 - 6. Publish Project Database: Allows the user to send a new project database to the server and download the new configuration to the system. The project database holds all the configuration information for the system, including keypad programming, area scenes, daylighting, occupancy programming, emergency levels, night lights, and time clock.
 - 7. Allows manufacturer (either remotely or with on-site service call); end-user (with training) to:
 - a. Capture system design:
 - 1) Geographical layout.
 - 2) Load schedule zoning.
 - 3) Equipment schedule.
 - 4) Equipment assignment to lighting management hubs.
 - 5) Daylighting design.
 - b. Define the configuration for the following in each area:
 - 1) Lighting scenes.
 - 2) Control station devices.
 - 3) Interface and integration equipment.
 - 4) Occupancy/after hours.
 - 5) Partitioning.
 - 6) Daylighting.
 - 7) Emergency lighting.
 - 8) Night lights.

c. Startup:

- 1) Addressing.
- 2) Daylighting.
- 3) Provide customized conditional programming.

C. Control and Monitor Software:

1. Product: Lutron Quantum Vue.
2. General Requirements:
 - a. Web-based; runs on most HTML5 compatible browsers (including Internet Explorer, Chrome, and Safari).
 - b. Supports multiple platforms and devices; runs from a tablet, desktop, laptop, or smartphone; optimized for displays of 1024 by 768 pixels or higher.
 - c. User interface supports multi-touch gestures such as pinch to zoom, drag to pan, etc.
 - d. Utilizes HTTPS (industry-standard certificate-based encryption and authentication for security).
 - e. All functionality listed below must be available via a single application.
3. System Navigation and Status Reporting:
 - a. Performed using graphical floor plan view or a generic system layout.
 - b. Graphical Floor Plan View: Utilizes customized CAD based drawing of the building. Pan and zoom feature allow for easy navigation; dynamically adjusts the details presented based on zoom level.
 - c. Area, scene, and zone names can be changed in real time.
 - d. Adjustments can be made based on area type.
4. Control of Lights:
 - a. Control and monitor zone/area lights.
 - 1) Area lights can be monitored for on/off status.
 - 2) All lights in an area can be turned on/off or sent to a specific level.
 - 3) For areas that have been zoned, these areas may be sent to a predefined lighting scene, and individual zones may be controlled.
 - 4) Area lighting scenes can be renamed and modified in real-time, changing the levels that zones go to when a scene is activated.
 - 5) High and low end of area lighting can be tuned/trimmed.
 - b. Control and monitor area partition status from a graphical floor plan.
5. Occupancy:
 - a. Area occupancy can be monitored.
 - b. Area occupancy can be disabled to override occupancy control or in case of occupancy sensor problems.
 - c. Area occupancy settings including level that lights turn on to when area is occupied, and level that lights turn off to when area is unoccupied can be changed in real-time.
 - d. Monitor energy savings due to occupancy down to an individual area.

6. Daylighting:
 - a. Daylighting can be enabled/disabled. Can be used to override the control currently taking place in the space.
 - b. Daylight calibration can be adjusted for each daylight area.
 - c. Daylight status can be monitored.
 - d. Monitor energy savings due to daylight harvesting down to an individual area.
7. Load Shedding; Lutron IntelliDemand: Allows the building manager to monitor whole building lighting power usage and apply a customized load shed reduction to selected areas, thereby reducing a building's power usage; load shedding triggered via Quantum Vue software or BACnet.
8. Scheduling: Schedule time of day and astronomic time clock events to automate functions.
 - a. Adjust or disable a single occurrence of a repeating scheduled event.
 - b. Easily monitor and adjust scheduled events using a weekly calendar view.
9. Reporting: Provide reporting capability that allows the building manager to gather real-time and historical information about the system as follows:
 - a. Energy Reports: Show a comparison of cumulative energy used over a period of time for one or more areas. Capable of displaying:
 - 1) Current savings in percent and kW.
 - 2) Historic energy savings in kWh saved.
 - 3) Historical views in time periods (days, weeks, months, years).
 - 4) Comparisons of historical periods (days, weeks, months, years).
 - b. Power Reports: Show power usage trend over a period of time for one or more areas.
 - c. Energy Density Report: Show energy usage in W/sq ft.
 - d. Energy Savings by Strategy Report: Show energy savings for any area broken down by strategy (tuning, occupancy, daylighting, scheduled events, personal control, and load shedding).
 - e. Space Utilization/Occupancy Reports: Show historical occupancy over a period of time for one or more areas using a graphical floor plan, generic system layout, and/or graphs and charts.
 - f. Activity Report: Show what activity has taken place over a period of time for one or more areas. Activity includes occupant activities (e.g. wall controls being pressed), building manager operation (e.g. controlling/changing areas using the control and monitor tool), and device failures (e.g. keypads or ballasts that are not responding).
 - g. Lamp Failure Report: Shows which areas are currently reporting lamp failures.
 - h. Sensor Level Report: Shows the light level in footcandles of any photosensor in the system.
 - i. Alert Activity Report: Capable of generating historical reports of all alert activity within the system.
10. Diagnostics: Allows the building manager to check on the status of all equipment in the lighting control system. Devices to be listed with a reporting status of OK, missing, or unknown.
11. Alerts and Alarms: Monitors the system for designated events/triggers and automatically generates alerts according to configured response criteria.

- a. Capable of monitoring for the following events/triggers:
 - 1) A failed piece of equipment (e.g. ballast, control, sensor, etc.); alert cleared when equipment is replaced.
 - 2) Low battery conditions in battery-operated sensors and controls; alert cleared when battery is replaced.
 - 3) Luminaires with lamp operating hours in excess of designated time.
 - 4) A load shed event; alert generated for beginning and end of trigger.
 - 5) Energy usage higher than designated threshold target.
 - 6) Potential light level condition discrepancies (daylight sensors not agreeing with expected lighting status).
 - 7) Potential sensor failures (Radio Window sensors that have not seen a change in light level).
 - b. View alerts on a customized graphical floor plan.
 - c. Capable of generating alerts through visible changes in software or through email messages.
 - d. Capable of customizing the frequency of alerts and providing notifications immediately or through daily, weekly, or monthly summaries.
 - e. Capable of sending different alerts to different system users.
 - f. Capable of generating historical reports of all alert activity within the system.
12. Administration:
- a. Users: Allows new user accounts to be created and existing user accounts to be edited.
 - 1) Supports Active Directory (LDAP) tying user accounts to network accounts.
 - b. Area and feature access can be restricted based on login credentials with assigned levels of access rights (Monitor, Control Only, Control and Edit, Admin) and customized access levels available.
 - c. Supports up to 20 concurrent users and 10,000 user accounts.
13. Quick Controls: Create shortcuts to activate customized system-wide actions, such as updating lighting and/or shade levels.
14. Provides control/monitoring of partition status to automatically reconfigure how the space operates based on the partition's open/closed status.
15. Variables: Used for custom program of a system and/or to signal a third party system. Any change may cause a change in the behavior of the system.
- a. View the current state of system variables across subsystems.
 - b. Update the current variable state across all subsystems.
16. Device Lock/Unlock: Allows the building manager to lock control station devices to prevent building occupants from activating their programming (button presses), until they are unlocked.
- a. Keypads can be locked to help ensure occupants cannot change light and shade levels in a public space during specific events or business hours.
 - b. Keypads can be unlocked after events/during after hours to allow maintenance, cleaning, security, and others to perform their tasks without needing to contact a building manager.

D. Quantum Mobile Control and Programming Software License:

1. Allows mobile control and programming of Quantum system via an Apple iPad or Windows 10 tablets/PCs.
2. Provides users the ability to:
 - a. Control and monitor area lighting scenes, zones, and shade presets.
 - b. Easily identify zones and shade groups.
 - c. Edit area lighting scenes, shade presets, scene fade rates, and scene delay rates.
 - d. Restrict user access by area.
 - e. Restrict users from ability to make changes.
3. Connects to Quantum system via:
 - a. An Ethernet connection directly to the processor or through the computer (server) in the system.
 - 1) If connecting to a server, it must be a server with only a single instance of Quantum system software.
 - b. Wi-Fi.

E. API Integration License:

1. Product: Lutron Model QSW-API; one license required per Quantum processor.
2. Support communication, without requiring interface, between lighting control system and third-party systems via RESTful API.
3. API Integration Capabilities:
 - a. Discovery:
 - 1) Areas: Area and scene names.
 - 2) Zones: Zone names, minimum and maximum light levels.
 - b. Monitoring:
 - 1) Area Information:
 - a) Occupancy status.
 - b) Occupancy enabled.
 - c) Lighting zone status.
 - d) Active scene.
 - e) Instantaneous and maximum lighting power.
 - 2) Zone Information:
 - a) Light intensity.
 - b) Switch level.
 - c) Contact closure output status.
 - d) Correlated color temperature (where controllable).
 - c. Control:
 - 1) Lighting Control:

- a) Activate scene.
- b) Set lighting zone level and correlated color temperature (where controllable).

F. Mobile Application:

- 1. Product: Lutron Quantum Lighting Designer App.
- 2. Enables system tuning and control from iOS mobile device.
- 3. Capabilities:
 - a. Control lighting zones and scenes.
 - b. Edit lighting scenes.
 - c. Control shade groups and presets.
 - d. Edit shade presets.
 - e. View and edit timeclock events.

2.15 LIGHTING MANAGEMENT SYSTEM COMPUTER

A. Server:

- 1. Suitable for 24 hour per day, 7 day per week programming, monitoring, control, and data logging of digital-network lighting controls.
- 2. Suitable to handle client machine request in multi-computer systems.
- 3. Unless otherwise indicated, computer to be provided by lighting control system manufacturer.
- 4. Minimum Hardware Requirements:
 - a. Processor: Quad Core Intel® Xeon®.
 - b. 8 GB Ram.
 - c. 250 GB hard drive (40 GB for application and database).
 - d. Two 10/100/1000 Ethernet network interfaces - one for communication with lighting management hubs and one for communication with corporate intranet to allow access from system PCs and/or energy saving display terminals. Only one Ethernet network interface is required if all lighting management hubs and client PCs are on the same network.
 - e. Monitor with 1280 x 1024 resolution.
 - f. 4 USB 2.0 ports.
 - g. Dedicated Graphics Card with 256 MB of memory (only required if running client software from the server).
- 5. Minimum Software Requirements:
 - a. Licensed installation of US English 64-bit Microsoft® Windows® Server 2008 R2, Windows Server 2012 R1, or Windows Server 2012 R2.
 - b. Microsoft® Internet Information Services (IIS) 7 or later.
 - c. Microsoft® Internet Explorer 9 or later.
 - d. Microsoft® .NET Framework 3.5.
 - e. Microsoft® .NET Framework 4.5.

- B. Computers Provided by Lighting Control System Manufacturer: Computer software to be preinstalled and tested prior to shipping.

2.16 ACCESSORIES

A. Emergency Lighting Interface:

1. Product : Lutron Model LUT-ELI.
2. Provides total system listing to UL 924 when used with lighting control system.
3. Senses all three phases of building power.
4. If power on any phase fails provides output to send lights controlled to defined levels. Lights to return to their previous intensities when normal power is restored.
5. Accepts contact closure input from fire alarm control panel.

2.17 SOURCE QUALITY CONTROL

A. See Section 01 4000 - Quality Requirements, for additional requirements.

B. Factory Testing; Lutron Standard Factory Testing:

1. Perform full-function factory testing on all completed assemblies. Statistical sampling is not acceptable.
2. Perform full-function factory testing on 100 percent of all ballasts and LED drivers.
3. Perform factory burn-in of 100 percent of all ballasts at 104 degrees F (40 degrees C).

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters [and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used]. Conceal raceway and cables except in unfinished spaces.
1. Install plenum cable in environmental airspaces, including plenum ceilings.
 2. Comply with requirements for cable trays specified in Section 260536 "Cable Trays for Electrical Systems."
 3. Comply with requirements for raceways and boxes specified in Section 260533.13 "Conduits for Electrical Systems."
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- D. Identify system components, wiring, cabling, boxes, cabinets, and terminals. Comply with identification requirements specified in Section 260553 "Identification for Electrical Systems."
- E. Label each device cable within 6 inch (152 mm) of connection to bus power supply or termination block.
- F. Engage a factory-authorized service representative to perform startup service.

3.2 FIELD QUALITY CONTROL

- A. Field tests must be witnessed by Architect, Engineer, and Owner.>.
- B. Manufacturer's Startup Services; Lutron Standard Startup Services:
 - 1. Manufacturer's authorized Service Representative to conduct minimum of two site visits to ensure proper system installation and operation.
 - 2. Conduct Pre-Installation visit to review requirements with installer as specified in Part 1 under "Administrative Requirements".
 - 3. Conduct site visit upon completion of lighting control system to perform system startup and verify proper operation:
 - a. Verify connection of power wiring and load circuits.
 - b. Verify connection and location of controls.
 - c. Energize lighting management hubs and download system data program.
 - d. Address devices.
 - e. Verify proper connection of panel links (low voltage/data) and address panel.
 - f. Download system panel data to dimming/switching panels.
 - g. Check dimming panel load types and currents and supervise removal of by-pass jumpers.
 - h. Verify system operation control by control.
 - i. Verify proper operation of manufacturer's interfacing equipment.
 - j. Verify proper operation of manufacturer's supplied PC and installed programs.
 - k. Configure initial groupings of ballast for wall controls, daylight sensors and occupancy sensors.
 - l. Train Owner's representative on system capabilities, operation, and maintenance.
 - m. Obtain sign-off on system functions.
 - n.
- C. On-Site Performance-Verification Walkthrough; Lutron LSC-WALK: Include as part of the base bid.
- D. Training:
 - 1. Include services of manufacturer's authorized Service Representative to perform on-site training of Owner's personnel on operation, adjustment, and maintenance of lighting control system as part of standard system start-up services.
 - a. Include training on software to be provided:
 - 1) Configuration software used to make system programming and configuration changes.
 - 2) Control and monitor.
 - 3) Energy savings display software.
 - 4) Personal web-based control software.
- E. Customer-Site Solution Training Visit; Lutron LSC-TRAINING: Include as part of the base bid.
- F. Tests and Inspections:
 - 1. Test each bus controller using local and remote controls.
- G. Nonconforming Work:

1. Lighting controls will be considered defective if they do not pass tests and inspections.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

H. Field Test Reports:

1. Prepare test and inspection reports, including a certified report that identifies bus controllers included and describes query results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.
2. Printed list of all points created from actual queries of all addressed control points to include lamps, ballasts, manual controls, and sensors.
3. Event log verifying the performance of all devices generating event messages to include occupancy sensors, control buttons, alarm messages, and any other change of value messages.

3.3 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, service agreement must include software support for two years.
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within [two] <Insert number> years from date of Substantial Completion. Upgrading software must include operating system and new or revised licenses for using software.
 1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

END OF SECTION

SECTION 260963
STAGE DIMMING INSTALLATION

PART 1- GENERAL

1.1 SUMMARY

- A. The General Provisions of the Contract, including Conditions of the Contract and Division 1 of the Specifications, apply to the work in this Section.
- B. The Electrical Contractor, herein referred to as the EC, shall provide all labor, materials, services and equipment to set, install, interconnect and test the dimming and control systems as shown on the drawings and as specified herein. Drawings, specifications and other related documents shall apply to all work of this section.
- C. Work of this Section includes, but is not limited to, the following:
 - 1. Installation of wiring devices, back boxes, panels, conduits, wiring, dimmer racks and modules, DMX 512 signal cable, Ethernet cable and lighting control racks provided by the Section 116153 contractor, including:
 - a. New stage lighting dimmer racks and relay panels.
 - b. New lighting control rack.
 - c. New architectural lighting low voltage control stations.
 - d. DMX 512 and Ethernet wiring devices.
 - e. New stage lighting wiring devices.
 - 2. Coordination with the Lighting System Integrator as specified in Section 116153 for a complete theatrical dimming system.
 - 3. Engineering as required by the Contract Documents.
 - 4. All power distribution devices, conduit and wire as required in this Section and related Specification Sections listed herein.
 - 5. Provide all disconnects and power feeds as required for dimmer racks and relay panels.
 - 6. Provide continuous liaison with the Construction Manager (CM) and other trades during demolition and construction, and coordinate delivery schedules and installation of equipment.
- D. Materials required for installation shall be as specified under Division 26.
- E. This specification shall be considered as an outline form and other appurtenances that may be required for the efficient and safe operation of the dimming and control systems specified in this section shall be furnished by the EC, the same as if specified herein.
- F. All work shall be manufactured and installed in accordance with the latest editions of applicable publications and standards of the following organizations:
 - 1. National Electric Code (NEC) and all prevailing local regulations
 - 2. Underwriters Laboratories, Inc. (UL)
 - 3. National Electrical Manufacturers Association (NEMA)

- 4. Federal Communication Commission (FCC)
- 5. Entertainment Services and Technology Association (ESTA)
- G. The EC shall provide all mounting and mechanical installations and shall verify all mounting conditions.
- H. Any materials installed which shall not present an orderly and reasonably neat or workmanlike appearance shall be removed and replaced, when so directed by the CM, at the EC's expense.
- I. Any quantities, measurements or dimensions listed or shown are for the convenience of the EC in the preparation of his estimate, but will not relieve the EC of his responsibility for the determination of the exact quantities, measurements and dimensions required for a complete job.

1.2 RELATED DOCUMENTS

- A. Division 1 - General and Supplementary Requirements
- B. Division 5 – Metals
- C. Section 116153 – Stage Dimming and Controls
- D. Section 116163 - Stage Lighting Fixtures
- E. Section 116133 - Stage Rigging
- F. Section 265113 – Architectural Lighting Fixtures

1.3 RELATED WORK BY OTHERS

- A. Stage Rigging
- B. Structural Steel (Catwalks)

1.4 DEFINITIONS

- A. "Owner" as used in this section shall mean the representative of Northeast Metropolitan Regional Vocational High School.
- B. "Theatre Consultant" as used in this section shall mean Studio T+L, LLC.
- C. "Lighting System Integrator" (LSI) as used in this section shall mean the contractor responsible to provide, furnish and/or install, as noted, the stage lighting and architectural lighting dimming and control system under Section 116153.
- D. "Architect" as used in this section shall mean Drummey Rosane Anderson, Inc.
- E. "Electrical Engineer" as used in this section shall mean _____.
- F. "Electrical Contractor" as used in this section shall mean the contractor for Division 26.
- G. Wherever the words "Approved", "Approval" and "Approved equal" appear, it is intended that items other than the model numbers specified shall be subject to the approval of the Architect and Theatre Consultant.
- H. "Provide", as used herein, shall mean that the EC is responsible for furnishing and installing said item or equipment.
- I. "Furnish", as used herein, shall mean that the EC shall acquire and make available said item or equipment and that the installation shall be by others.
- J. "Install", as used herein, shall mean that the EC shall make installation of items or equipment furnished by others.

- K. "Contract Documents" as used in this section shall be deemed to include both the specification section and related bid drawings.
- L. "NIC" as used in the contract documents means "Not included in this subcontract".
- M. "By Others" as used in the contract documents means "Provided by another subcontractor".
- N. "Or As Approved" as used in the contract documents means "Substitution only after written approval by Consultant."

1.5 SYSTEM OUTLINE

- A. The theatrical lighting system consists of wiring devices, both low and line voltage, theatrical relay panels, lighting control rack, and remote control consoles.
- B. The DMX 512 and Ethernet control signals shall be generated by various consoles and devices and shall be connected to the dimmer racks and relay panels via conduit runs and appropriate low voltage cables specified herein. Access to the DMX 512 and Ethernet networks shall be provided via the Lighting Control Rack.
- C. All equipment shall be the coordinated system integrated by the LSI in coordination with the EC.
- D. The specified dimming and control components are called out in terms of products as manufactured by Electronic Theater Controls. This equipment is fully described in the Contract Documents. Complete technical data is also available from the manufacturers. All catalog numbers are those shown on manufacturer's data sheets and drawings unless otherwise noted.
- E. The power equipment, wiring devices and control devices shall be furnished by the Section 116153 contractor, and set into place and installed by the EC. It shall be the EC's responsibility to run all conduits and wiring for line and low voltage circuits and make terminations at the wiring devices.
- F. When the EC is finished, a fully working and tested system, as described in sections 3.4 and 3.5 herein, will be turned over to the Owner. If mention has been omitted of any items of the work or materials usually furnished for, or necessary to, the completion of the electrical work or if there are conflicting points in the specifications and/or drawings, the Architect's attention should be called to such items in sufficient time for a formal addendum to be issued.

1.6 BIDDING

- A. The EC shall examine all drawings prior to submitting his bid. He shall note all adverse conditions to be overcome or circumvented, and all favorable conditions to be taken advantage of. Submittal of a bid will indicate that the EC has full knowledge of the problems involved in the work and that he has taken these into consideration in computing his bid.
- B. The EC shall include the cost to set and interconnect the dimming system components as specified in Section 116153 in his base bid proposal along with any additional materials required to implement the system such as conduit, panel boxes and wire as specified in the Contract Documents.
- C. In addition to the submittals required under the general conditions of these specifications, all bidders are required to furnish supporting documents as noted below in order for their bids to be considered.
- D. The Owner reserves the right to waive all formalities, to be sole judge of quality and equality of the several bid proposals and reserves the right to reject any and all bids.

1.7 PROJECT CONDITIONS

- A. All theatrical lighting equipment shall be furnished by the Section 116153 contractor and installed under this Section.
- B. All equipment furnished to the job site by the LSI shall become the responsibility of the EC at the time of delivery by the System Integrator. The LSI will provide a Bill of Materials to be reviewed with the EC for signature acknowledging receipt of all items in excellent condition. At this time the EC shall document the exact condition, breakage or damage evident in the equipment. Exact quantities shall be documented. Any discrepancies in the quantities and any damage or unsuitability of the product for the application shall be provided in writing to the LSI upon transfer of the equipment. Acceptance of the equipment verifies proper physical condition of the product. Electrical functionality is not implied at acceptance and is not the responsibility of the EC. The LSI shall be present at the time of transfer to coordinate and expedite this action. The LSI shall be given a two week minimum lead time prior to this meeting. Copies of the signed Bill of Materials shall be forwarded to the Theatre Consultant and to the Electrical Engineer.
- C. Provide continuous liaison with the CM and LSI during demolition and construction, and coordinate delivery schedules and installation of equipment with related trades.

1.8 COMPLETION DATE

- A. Completion of the entire dimming system shall be according to the project schedule.
- B. A final check-out by the Architect and Theatre Consultant and a reasonable allowance of time to complete "punch-list" items must be included in the EC's and LSI's planning and job schedule.

PART 2 – PRODUCTS

2.1 MATERIALS

- A. Materials required for installation shall be as specified under Division 26000.
- B. The specified dimming and control components are called out under Section 116153.
- C. Recessed and surface mounted back boxes shall be as furnished under Section 116153 of these Specifications. Boxes shall have no knockouts and shall be punched on site to make a clean, safe installation.
- D. Low voltage cable shall be furnished under this Section as recommended by the LSI.
- E. Permanently installed data cables used to transmit "DMX" or "DMX512" data shall comply with the rules and recommendations of the following standard: ANSI E1.27-2 – 2009 (R2014), Entertainment Technology - Recommended Practice for Permanently Installed Control Cables for Use with ANSI E1.11 (DMX512-A) and USITT DMX512/1990 Products.

PART 3 – EXECUTION

3.1 SUBMITTALS

- A. The EC shall, if requested by the Theatre Consultant, furnish satisfactory evidence as to kind and quality of materials he proposes to furnish by submission of exact samples of materials intended for installation. If required, these samples shall be submitted with shop drawings. Any such samples shall be returned.
- B. Handling, shipping and delivery to, or removal from the site, of any sample required shall be at the cost of the EC.

3.2 DELIVERY

- A. All equipment under Section 116153 shall be furnished to the job site by the LSI and shall become the responsibility of the EC at time of delivery. All other materials required to complete this contract shall be delivered by the EC to the project site.

3.3 SYSTEM COMMISSIONING

- A. At no time shall the equipment furnished under Section 116153 be energized prior to the LSI authorized commissioning.
- B. The EC shall provide at least two (2) weeks notice to the LSI to coordinate and schedule the system commissioning.
- C. The EC shall confirm in writing that the following conditions have been met prior to scheduling system commissioning:
 - 1. Arrangements shall be made for access to all equipment.
 - a. Scaffolding, lifts or any other OSHA approved method shall be acceptable.
 - 2. All dimmer racks shall be installed and wired.
 - 3. Tagged control cable shall be installed and 24" tails left for the SI to terminate.
 - 4. All distribution equipment shall be completely installed.
 - 5. Continuity checks for the entire system shall have been performed and failures remedied.
 - 6. At the time of commissioning the EC shall provide a representative who has full working knowledge of the system, device placement and job conditions. This representative shall be on-site throughout the commissioning process and shall coordinate with, and aid, the LSI to expeditiously commission the system.

3.4 INSPECTION AND TESTING

- A. Field Check-Out and Final Approvals
 - 1. Furnish all equipment and instruments necessary for testing the complete wiring system during the progress of the work as well as after installation. Tests shall be demonstrated to the satisfaction of the Owner. Test the following:
 - a. All circuits are continuous and free from short circuits.
 - b. All circuits are free from unspecified grounds.
 - c. All circuits are properly connected in accordance with the applicable wiring diagram.
 - d. Voltage drop at each end of the circuit with a 2000 watt load is within 2% tolerance.
 - e. All low voltage circuits comply with industry standards.
 - 2. Final Check of House, Work and Stage Control System
 - a. All work under this contract, upon completion of installation, shall be demonstrated, tested and adjusted in coordination with the LSI and the EC. No part of the system shall be energized before being so checked and the installation approved.
 - b. Make all necessary arrangements for all parties concerned to be present, by scheduling such inspection in a manner acceptable to the Theatre Consultant and give a minimum of 14 days notice.
 - c. Furnish all labor, materials and instruments necessary for this inspection and testing.
 - 3. Final site visitation by Theatre Consultant

- a. When the work on the entire structure has been completed and is ready for final review, a visit will be made by the Theatre Consultant or his duly authorized representative, at which time the LSI shall demonstrate that the requirements of the contract as it applies to his work have been carried out and that the system has been adjusted and operates in accordance therewith.
- b. Any defects shall be repaired at once and the tests re-conducted.

3.5 CLEAN UP

- A. Upon completion inspect entire lighting equipment installation and clean all surfaces, make all necessary adjustments, remove all protective coverings, dirt, dust, finger marks, smears, contamination, extraneous materials and foreign matter and leave entire installation in clean and properly serviced, finished and operating condition.
- B. The EC shall gather in one place and at one time all loose equipment, keys and as-built drawings to be turned over to the Owner. He shall have all items listed and typed on a sheet of paper ready to be signed by an authorized representative of the Owner.
- C. The entire installation will not be ready for acceptance until it is functioning properly to the satisfaction of the Theatre Consultant.

3.6 GUARANTEE

- A. The Division 26 contractor shall guarantee in writing that all material and workmanship to the apparatus installed under this contract are first class in every respect and conform to the operating design criteria specified. Make good any defects, mechanical or electrical, not due to ordinary wear and tear or improper use or care, which may develop within a period of one (1) year, beginning from the day of final acceptance of the work by the Owner.
- B. The EC shall also, during this one (1) year guarantee period, be responsible for the proper adjustments of all systems, equipment and apparatus installed by him and do all work necessary to insure efficient and proper functioning of the systems and equipment.
- C. Any equipment malfunctions due to equipment failure or poor installation, shall be made good or be replaced as directed by the Architect or the Owner, at no cost to the Owner and at such times as designated by the Owner.

END SECTION 260963

SECTION 262213

LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section includes distribution, dry-type transformers with a nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type and size of transformer.
 - 2. Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer.
- B. Shop Drawings:
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
 - 3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Seismic Qualification Data: Certificates, for transformers, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
 - 4. Certification: Indicate that equipment meets project seismic requirements.
- C. Source quality-control reports.

LOW-VOLTAGE BUCK-BOOST TRANSFORMERS

- D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.

- 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Inspection: On receipt, inspect for and note any shipping damage to packaging and transformer.
 - 1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.
- B. Storage: Store in a warm, dry, and temperature-stable location in original shipping packaging.
- C. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.
- D. Handling: Follow manufacturer's instructions for lifting and transporting transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton.
 - 2. Schneider Electric USA (Square D).
 - 3. Siemens Industry, Inc., Energy Management Division.
 - 4. Hammond Power Solutions
 - 5. REX Power Magnetic
- B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Transformers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the transformer will remain in place without separation of any parts when subjected to the seismic forces specified."

2.3 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- B. Comply with NFPA 70.
 - 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- C. Transformers Rated 15 kVA and Larger:
 - 1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
 - 2. Marked as compliant with DOE 2016 efficiency levels by an NRTL.
- D. Shipping Restraints: Paint or otherwise color-code bolts, wedges, blocks, and other restraints that are to be removed after installation and before energizing. Use fluorescent colors that are easily identifiable inside the transformer enclosure.

2.4 DISTRIBUTION TRANSFORMERS

- A. Comply with NFPA 70
- B. Provide transformers that are constructed to withstand seismic forces specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- C. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.
 - 1. One leg per phase.
 - 2. Core volume shall allow efficient transformer operation at 10 percent above the nominal tap voltage.
 - 3. Grounded to enclosure.
- D. Coils: Continuous windings without splices except for taps.
 - 1. Coil Material: Copper.
 - 2. Internal Coil Connections: Brazed or pressure type.
 - 3. Terminal Connections: Welded.
- E. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.
- F. Enclosure: Ventilated.
 - 1. NEMA 250,: Core and coil shall be encapsulated within resin compound to seal out moisture and air.
 - 2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
 - 3. Wiring Compartment: Sized for conduit entry and wiring installation.
 - 4. Finish: Comply with NEMA 250.
 - a. Finish Color: Gray weather-resistant enamel.
- G. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.

- H. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.
- I. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
 - 1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor, without exceeding the indicated insulation class in a 40 deg C maximum ambient and a 24-hour average ambient of 30 deg C.
 - 2. Indicate value of K-factor on transformer nameplate.
 - 3. Unit shall comply with requirements of DOE 2016 efficiency levels when tested according to NEMA TP 2 with a K-factor equal to one.
- J. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
 - 1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
 - 2. Include special terminal for grounding the shield.
- K. Neutral: Rated 200 percent of full load current for K-factor-rated transformers.
- L. Wall Brackets: Manufacturer's standard brackets.
- M. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:
 - 1. 9.00 kVA and Less: 40 dBA.
 - 2. 9.01 to 30.00 kVA: 45 dBA.
 - 3. 30.01 to 50.00 kVA: 45 dBA for K-factors of 1, 4, and 9.

2.5 IDENTIFICATION

- A. Nameplates: Engraved, laminated-acrylic or melamine plastic signs for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."
- B. Nameplates: Self-adhesive label for each distribution transformer. Self-adhesive labels are specified in Section 260553 "Identification for Electrical Systems."

2.6 SOURCE QUALITY CONTROL

- A. Test and inspect transformers according to IEEE C57.12.01 and IEEE C57.12.91.
 - 1. Resistance measurements of all windings at rated voltage connections and at all tap connections.
 - 2. Ratio tests at rated voltage connections and at all tap connections.
 - 3. Phase relation and polarity tests at rated voltage connections.
 - 4. No load losses, and excitation current and rated voltage at rated voltage connections.
 - 5. Impedance and load losses at rated current and rated frequency at rated voltage connections.
 - 6. Applied and induced tensile tests.

7. Regulation and efficiency at rated load and voltage.
8. Insulation-Resistance Tests:

- a. High-voltage to ground.
- b. Low-voltage to ground.
- c. High-voltage to low-voltage.

9. Temperature tests.

- B. Factory Sound-Level Tests: Conduct prototype sound-level tests on production-line products.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E. Environment: Enclosures shall be rated for the environment in which they are located. Covers for NEMA 250, Type 4X enclosures shall not cause accessibility problems.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wall-mounted transformers level and plumb with wall brackets fabricated [by transformer manufacturer] [from design drawings signed and sealed by a licensed structural engineer].
 1. Coordinate installation of wall-mounted and structure-hanging supports with actual transformer provided.
 2. Brace wall-mounted transformers as specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- B. Install transformers level and plumb on a concrete base with vibration-dampening supports. Locate transformers away from corners and not parallel to adjacent wall surface.
- C. Construct concrete bases according to Section 033000 "Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions and requirements in Section 260529 "Hangers and Supports for Electrical Systems."

1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

- D. Secure transformer to concrete base according to manufacturer's written instructions.
- E. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.
- F. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- D. Provide flexible connections at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections with the assistance of a factory-authorized service representative].
- E. Small (Up to 167-kVA Single-Phase or 500-kVA Three-Phase) Dry-Type Transformer Field Tests:
 1. Visual and Mechanical Inspection.
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, and grounding.
 - c. Verify that resilient mounts are free and that any shipping brackets have been removed.
 - d. Verify the unit is clean.
 - e. Perform specific inspections and mechanical tests recommended by manufacturer.
 - f. Verify that as-left tap connections are as specified.
 - g. Verify the presence of surge arresters and that their ratings are as specified.

2. Electrical Tests:

- a. Measure resistance at each winding, tap, and bolted connection.
 - b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
 - c. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
 - d. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
- F. Large (Larger Than 167-kVA Single Phase or 500-kVA Three Phase) Dry-Type Transformer Field Tests:
 1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, and grounding.
 - c. Verify that resilient mounts are free and that any shipping brackets have been removed.
 - d. Verify the unit is clean.
 - e. Perform specific inspections and mechanical tests recommended by manufacturer.
 - f. Verify that as-left tap connections are as specified.
 - g. Verify the presence of surge arresters and that their ratings are as specified.
 2. Electrical Tests:
 - a. Measure resistance at each winding, tap, and bolted connection.
 - b. Perform insulation-resistance tests winding-to-winding and each winding-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: the value of the index shall not be less than 1.0.
 - c. Perform power-factor or dissipation-factor tests on all windings.
 - d. Perform turns-ratio tests at all tap positions. Test results shall not deviate by more than one-half percent from either the adjacent coils or the calculated ratio. If test fails, replace the transformer.
 - e. Perform an excitation-current test on each phase.
 - f. Perform an applied voltage test on all high- and low-voltage windings to ground. See IEEE C57.12.91, Sections 10.2 and 10.9.
 - g. Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
- G. Remove and replace units that do not pass tests or inspections and retest as specified above.
- H. Infrared Scanning: Two months after Substantial Completion, perform an infrared scan of transformer connections.
 1. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
 2. Perform two follow-up infrared scans of transformers, one at four months and the other at 11 months after Substantial Completion.
 3. Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.

- I. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

- A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
- B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION

SECTION 262413

SWITCHBOARDS

PART 1 - GENERAL

1.1 SUMMARY

- A. Products installed, but not furnished under this Section:
 - 1. Fabrication and delivery of Switchboard to future Electrical Subcontractors rigging yard within 50 miles of site
- B. Section Includes:
 - 1. Switchboards.
 - 2. Surge protection devices.
 - 3. Disconnecting and overcurrent protective devices.
 - 4. Instrumentation.
 - 5. Control power.
 - 6. Accessory components and features.
- C. Related Requirements
 - 1. Section 260573.19 "Arc-Flash Hazard Analysis" for arc-flash analysis and arc-flash label requirements.

1.2 COORDINATION

- A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. Switchboards.
 - 2. Overcurrent protective devices.
 - 3. Surge protection devices.
 - 4. Ground-fault protection devices.
 - 5. Accessories.
 - 6. Other components.
 - 7. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
- B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
 2. Detail enclosure types for types other than UL 50E, Type 1.
 3. Detail bus configuration, current, and voltage ratings.
 4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
 5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
 6. Detail utility company's metering provisions with indication of approval by utility company.
 7. Include evidence of listing, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for series rating of installed devices.
 8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
 10. Include diagram and details of proposed mimic bus.
 11. Include schematic and wiring diagrams for power, signal, and control wiring.
- C. Samples: Representative portion of mimic bus with specified material and finish, for color selection.
- D. Field Quality-Control Submittals:
1. Field Quality-Control Reports:
 - a. Test procedures used.
 - b. Test results that comply with requirements.
 - c. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturers' Published Instructions: Record copy of official installation instructions issued to Installer by manufacturer for the following:
1. Handling, storing, and providing temporary heat.
 2. Mounting accessories and anchoring devices.
 3. Testing and adjusting overcurrent protective devices.
- B. Sample warranties.

1.5 CLOSEOUT SUBMITTALS

- A. Warranty documentation.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Spare Parts: Furnish to Owner spare parts, for repairing switchboards, that are packaged with protective covering for storage on-site and identified with labels describing contents.
1. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type but no fewer than two of each size and type.

2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
 4. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
 5. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
 6. Indicating Lights: Equal to 10 percent of quantity installed for each size and type but no less than one of each size and type.
- B. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to switchboards, that are packaged with protective covering for storage on-site and identified with labels describing contents.
- C. Retain "Accessory Set" Subparagraph below for drawout circuit breakers.
1. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
 2. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.
 3. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
- B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section to prevent condensation.
- C. Handle and prepare switchboards for installation in accordance with NEMA PB 2.1.

1.8 WARRANTY

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed switchboard perform in accordance with specified requirements and agrees to repair or replace components that fail to perform as specified within extended-warranty period.
1. Extended-Warranty Period: 1 year from date of Substantial Completion; full coverage for labor, materials, and equipment.

1.9 SWITCHBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton.
 2. Siemens Industry, Inc., Energy Management Division.
 3. Square D; Schneider Electric USA.

- B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- E. Comply with NEMA PB 2.
- F. Comply with NFPA 70.
- G. Comply with UL 891.
- H. Front-Connected, Front-Accessible Switchboards:
 - 1. Main Devices: Fixed individually mounted.
 - 2. Branch Devices: Panel mounted.
 - 3. Sections front and rear aligned.
- I. Nominal System Voltage: 480Y/277 V.
- J. Main-Bus Continuous: 4000 A.
- K. Indoor Enclosures: Steel, UL 50E, Type 1.
- L. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over rust-inhibiting primer on treated metal surface.
- M. Insulation and isolation for main bus of main
- N. Service Entrance Rating: Switchboards intended for use as service entrance equipment may contain from one to six service disconnecting means with overcurrent protection, neutral bus with disconnecting link, grounding electrode conductor terminal, and main bonding jumper.
- O. Utility Metering Compartment: Barrier compartment and section complying with utility company's requirements; hinged sealable door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.
- P. Customer Metering Compartment: Separate customer metering compartment
- Q. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- R. Buses and Connections: Three phase, four wire unless otherwise indicated.
 - 1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from front of switchboard.
 - 2. Phase- and Neutral-Bus Material:

- a. Hard-drawn copper of 98 percent conductivity
3. Copper feeder circuit-breaker line connections.
4. Ground Bus: Minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with connectors for feeder and branch-circuit ground conductors.
5. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
6. Disconnect Links:
 - a. Isolate neutral bus from incoming neutral conductors.
 - b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.
7. Neutral Buses: **100** percent of ampacity of phase buses unless otherwise indicated, equipped with connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
8. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

1.10 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker (MCCB): Power Defense style Comply with UL 489, with full interrupting capacity to meet available fault currents.
 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. Electronic trip circuit breakers PXR style over 600A frame sizes with RMS sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long and short time adjustments.
 3. MCCB Features and Accessories where shown on drawings:
 - a. Ground-Fault Protection: Integrally mounted PXR trip unit with adjustable pickup and time-delay settings, and ground-fault indicator.
 - b. Communication Capability: Circuit-breaker-mounted compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
 - c. Shunt Trip: 120 V trip coil energized from separate circuit, set to trip at [55] [75] percent of rated voltage.
 - d. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - e. Auxiliary Contacts: with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 - f. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key must be removable only when circuit breaker is in off position.
- B. Insulated-Case Circuit Breaker (ICCB): 100 percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.

1. **Fixed** circuit-breaker mounting.
 2. Two-step, stored-energy closing.
 3. Standard-function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Time adjustments for long- and short-time pickup.
 4. Accessories where shown on drawings
 - a. Ground-fault pickup level, time delay, and I^2t response.
 - b. Remote trip indication and control.
 - c. Communication Capability: Web enabled integral Ethernet communication module and embedded Web server with factory-configured Web pages (HTML file format). Provide functions and features compatible with power monitoring and control system specified in Section 260913 "Electrical Power Monitoring and Control."
 - d. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key must be removable only when circuit breaker is in off position.
- C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
- D. Fuses are specified in Section 262813 "Fuses."
- 1.11 INSTRUMENTATION
- A. Instrument Transformers: NEMA EI 21.1, and the following:
1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz, secondary; disconnecting type with integral fuse mountings. Burden and accuracy must be consistent with connected metering and relay devices.
 2. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary; winding and secondary shorting device. Burden and accuracy must be consistent with connected metering and relay devices.
 3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
 4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.
- B. Multifunction Digital-Metering Monitor: PX 1000 Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
 - d. Megawatts: Plus or minus 1 percent.
 - e. Megavars: Plus or minus 1 percent.
 - f. Power Factor: Plus or minus 1 percent.
 - g. Frequency: Plus or minus 0.1 percent.

- h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
 - i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.
 - j. Contact devices to operate remote impulse-totalizing demand meter.
- 2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

1.12 ACCESSORY COMPONENTS AND FEATURES

- A. Mounting Accessories: For anchors, mounting channels, bolts, washers, and other mounting accessories, comply with requirements in Section 260548.16 "Seismic Controls for Electrical Systems" or manufacturer's instructions.

PART 2 - EXECUTION

2.1 EXAMINATION

- A. Receive, inspect, handle, and store switchboards in accordance with NEMA PB 2.1.
 - 1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's published instructions.
 - 2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
 - 3. Protect from moisture, dust, dirt, and debris during storage and installation.
 - 4. Install temporary heating during storage in accordance with manufacturer's published instructions.
- B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.
- C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect performance of equipment.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

2.2 PREPARATION

- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

2.3 INSTALLATION

- A. Comply with manufacturer's published instructions.
- B. Reference Standards:
 - 1. Switchboards and Accessories: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NEMA PB 2.1.
 - 2. Consult Architect for resolution of conflicting requirements.

C. Special Techniques:

1. Equipment Mounting: Install switchboards on concrete base, 4 inch nominal thickness. Comply with requirements for concrete base specified in Section 260529 "Hangers and Supports for Electrical Systems."
 - a. Install conduits entering underneath switchboard, entering under vertical section where conductors will terminate. Install with couplings flush with concrete base. Extend 2 inch above concrete base after switchboard is anchored in place.
 - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18 inch centers around full perimeter of concrete base.
 - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, published instructions, and directions furnished with items to be embedded.
 - e. Install anchor bolts to elevations required for proper attachment to switchboards.
 - f. Anchor switchboard to building structure at top of switchboard if required or recommended by manufacturer.
2. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.
3. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
4. Operating Instructions: Frame and mount printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
5. Install filler plates in unused spaces of panel-mounted sections.
6. Install overcurrent protective devices, surge protection devices, and instrumentation.
 - a. Set field-adjustable switches and circuit-breaker trip ranges.
7. Install spare-fuse cabinet.

2.4 CONNECTIONS

- A. Comply with requirements for terminating feeder bus specified in Section 262500 "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.
- B. Comply with requirements for terminating cable trays specified in Section 260536 "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.
- C. Bond conduits entering underneath switchboard to equipment ground bus with bonding conductor sized in accordance with NFPA 70.
- D. Support and secure conductors within switchboard in accordance with NFPA 70.
- E. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

2.5 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Switchboard Nameplates: Label each switchboard compartment with nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- D. Mimic Bus:
 - 1. Entire single-line switchboard bus work, as depicted on factory record drawing, on minimum 0.032 inch thick anodized aluminum photoengraved nameplate, located at eye level on front cover of switchboard incoming service section.
 - 2. Entire single-line switchboard bus work, as depicted on factory record drawing, on engraved minimum 0.0625 inch thick laminated-plastic (Gravoply) nameplate, located at eye level on front cover of switchboard incoming service section.
 - 3. Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram.
 - 4. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce concise visual presentation of principal switchboard components and connections.
 - 5. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.
- E. Service Equipment Label: Labeled, by qualified electrical testing laboratory recognized by authorities having jurisdiction, for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

2.6 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Acceptance Testing:
 - a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within switchboard and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
 - b. Test continuity of each circuit.
 - 2. Test ground-fault protection of equipment for service equipment in accordance with NFPA 70.
 - 3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 5. Perform the following infrared scan tests and inspections, and prepare reports:

- a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared scan of each switchboard. Remove panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.
 - c. Instruments and Equipment:
 - 1) Use infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Nonconforming Work:
1. Switchboard will be considered defective if it does not pass tests and inspections.
 2. Remove and replace defective units and retest.
- C. Collect, assemble, and submit test and inspection reports, including certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

2.7 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573.16 "Coordination Studies."

2.8 PROTECTION

- A. Temporary Heating: Apply temporary heat, to maintain temperature in accordance with manufacturer's published instructions, until switchboard is ready to be energized and placed into service.

END OF SECTION

SECTION 262416

PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Lighting and appliance branch-circuit panelboards.

1.3 DEFINITIONS

- A. ATS: Acceptance testing specification.
- B. GFCI: Ground-fault circuit interrupter.
- C. GFEP: Ground-fault equipment protection.
- D. HID: High-intensity discharge.
- E. MCCB: Molded-case circuit breaker.
- F. SPD: Surge protective device.
- G. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of panelboard.
 - 1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.
 - 2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details.
 - 2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
 - 3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
 - 4. Detail bus configuration, current, and voltage ratings.
 - 5. Short-circuit current rating of panelboards and overcurrent protective devices.

6. Include evidence of NRTL listing for series rating of installed devices.
7. Include evidence of NRTL listing for SPD as installed in panelboard.
8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
9. Include wiring diagrams for power, signal, and control wiring.
10. Key interlock scheme drawing and sequence of operations.
11. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device. Include an Internet link for electronic access to downloadable PDF of the coordination curves.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Panelboard Schedules: For installation in panelboards, submit final versions after load balancing.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Keys: Two spares for each type of panelboard cabinet lock.
 2. Circuit Breakers Including GFCI and GFEP Types: Two spares for each panelboard.

1.8 QUALITY ASSURANCE

- A. Manufacturer Qualifications: ISO 9001 or ISO 9002 certified.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.

1.10 FIELD CONDITIONS

- A. Environmental Limitations:
 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding minus 22 deg F to plus 104 deg F.
 - b. Altitude: Not exceeding 6600 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet.

C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:

1. Notify Architect no fewer than two days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Architect's written permission.
3. Comply with NFPA 70E.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 18 months from date of Substantial Completion.

B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.

1. SPD Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NEMA PB 1.
- E. Comply with NFPA 70.
- F. Enclosures: Surface-mounted, dead-front cabinets.
 1. Rated for environmental conditions at installed location.

- a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 2. Height: 84 inches maximum.
 3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.
 4. Hinged Front Cover: Entire front trim hinged to box and with door-in-door construction within hinged cover. Trims shall cover all live parts and shall have no exposed hardware.
 5. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
 6. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
 7. Finishes:
 - a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Same finish as panels and trim.
 - c. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components.
- G. Incoming Mains:
1. Location: Convertible between top and bottom.
 2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.
- H. Phase, Neutral, and Ground Buses:
1. Material: Tin-plated aluminum.
 - a. Plating shall run entire length of bus.
 - b. Bus shall be fully rated the entire length.
 2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
 3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 4. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
 5. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
 6. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and listed and labeled by an NRTL acceptable to authority having jurisdiction, as suitable for nonlinear loads in electronic-grade panelboards and others designated on Drawings. Connectors shall be sized for double-sized or parallel conductors as indicated on Drawings. Do not mount neutral bus in gutter.
 7. Split Bus: Vertical buses divided into individual vertical sections.
- I. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Tin-plated aluminum.
 2. Terminations shall allow use of 75 deg C rated conductors without derating.

3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
 4. Main and Neutral Lugs: Compression type, with a lug on the neutral bar for each pole in the panelboard.
 5. Ground Lugs and Bus-Configured Terminators: Compression type, with a lug on the bar for each pole in the panelboard.
 6. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 7. Subfeed Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 8. Gutter-Tap Lugs: Compression type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.
- J. Future Devices: Panelboards or load centers shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
1. Percentage of Future Space Capacity: 20 percent.
- K. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include label or manual with size and type of allowable upstream and branch devices listed and labeled by an NRTL for series-connected short-circuit rating.
1. Panelboards rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
 2. Panelboards rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.
- L. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.
1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
 2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.
- ## 2.2 PERFORMANCE REQUIREMENTS
- A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
- B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 1.
- ## 2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton.

2. Schneider Electric USA (Square D).
 3. Siemens Industry, Inc., Energy Management Division.
- B. MCCB: Comply with UL 489, with series-connected rating to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers:
 - a. Inverse time-current element for low-level overloads.
 - b. Instantaneous magnetic trip element for short circuits.
 - c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 3. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 4. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
 5. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
 6. Arc-Fault Circuit Interrupter Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
 7. Subfeed Circuit Breakers: Vertically mounted.

2.4 IDENTIFICATION

- A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.
- B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.
- C. Circuit Directory: Directory card inside panelboard door, mounted in metal frame with transparent protective cover.
1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.
- D. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.
1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.5 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.
- B. Receive, inspect, handle, and store panelboards according to NECA 407.
- C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.
- D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Comply with NECA 1.
- C. Install panelboards and accessories according to NECA 407.
- D. Equipment Mounting:
 - 1. Attach panelboard to the vertical finished or structural surface behind the panelboard.
 - 2. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- F. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- G. Mount top of trim 90 inches above finished floor unless otherwise indicated.
- H. Mount panelboard cabinet plumb and rigid without distortion of box.
- I. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- J. Mount surface-mounted panelboards to steel slotted supports 1-1/4 inch in depth. Orient steel slotted supports vertically.
- K. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.
 2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.
- L. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.
- M. Install filler plates in unused spaces.
- N. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.
- O. Arrange conductors in gutters into groups and bundle and wrap with wire ties.
- P. Mount spare fuse cabinet in accessible location.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Acceptance Testing Preparation:
1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 2. Test continuity of each circuit.

D. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA ATS, Paragraph 7.6 Circuit Breakers optional tests. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each panelboard. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each panelboard 11 months after date of Substantial Completion.
 - c. Instruments and Equipment:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

E. Panelboards will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573.16 "Coordination Studies."
- C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.
 1. Measure loads during period of normal facility operations.
 2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
 4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.6 PROTECTION

- A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION

SECTION 262713

ELECTRICITY METERING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Work to accommodate utility company revenue meters, and Owner's electricity meters used to manage electrical power system.

1.2 DEFINITIONS

- ###### A. KY or KYZ Pulse:
- Term used by metering industry to describe method of measuring consumption of electricity (kWh) that is based on relay opening and closing in response to rotation of disk in meter. Electronic meters generate pulses electronically.

1.3 COORDINATION

A. Electrical Service Connections:

1. Coordinate with utility companies and utility-furnished components.
 - a. Comply with requirements of utility providing electrical power services.
 - b. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

1.4 ACTION SUBMITTALS

A. Product Data:

1. For each type of meter.
2. For metering infrastructure components.
3. For metering software.

B. Shop Drawings: For electricity-metering equipment.

1. Include elevation views of front panels of control and indicating devices and control stations.
2. Include diagrams for power, signal, and control wiring.
3. Wire Termination Diagrams and Schedules: Include diagrams for power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
4. Include series-combination rating data for modular meter centers with main disconnect device.
5. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators,

and other devices used. Describe characteristics of network and other data communication lines.

C. Field Quality-Control Submittals:

1. Field quality-control reports.

1.5 INFORMATIONAL SUBMITTALS

A. Manufacturers' Published Instructions: Record copy of official installation[**and testing**] instructions issued to Installer by manufacturer for the following:

1. Installation of metering equipment.

B. Sample warranties.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Contracts:

1. Software and firmware service agreement.

B. Warranty documentation.

1.7 WARRANTY

A. Special Installer Extended Warranty: Installer warrants that fabricated and installed metering equipment performs in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.

1. Extended-Warranty Period: Two years from date of Substantial Completion; full coverage for labor, materials, and equipment.

B. Special Manufacturer Extended Warranty: Manufacturer warrants that metering equipment performs in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.

1. Extended-Warranty Period: Three years from date of Substantial Completion; full coverage for labor, materials, and equipment.
2. Follow-On Extended-Warranty Period: Eight years from date of Substantial Completion; full coverage for materials **that** failed because of transient voltage surges only, free on board **origin**, freight prepaid.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

B. Comply with UL 916.

2.2 UTILITY METERING INFRASTRUCTURE

- A. Install metering accessories furnished by utility company, complying with its requirements.
- B. Utility-Furnished Meters: Connect data transmission facility of metering equipment installed by Utility.
 - 1. Data Transmission: Transmit pulse data over control-circuit conductors, classified as Class 1 per NFPA 70, Article 725. Comply with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.
- D. Meter Sockets:
 - 1. Comply with requirements of electrical-power utility company.
 - 2. Meter Sockets: Steady-state and short-circuit current ratings must meet indicated circuit ratings.
- E. Modular Meter Center: Factory-coordinated assembly of main **service terminal box with lugs only**, wireways, meter socket modules, and feeder circuit breakers arranged in adjacent vertical sections complete with interconnecting buses.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB, Electrification Business.
 - b. Eaton.
 - c. Leviton Manufacturing Co., Inc.
 - d. Siemens Industry, Inc., Energy Management Division.
 - e. Square D; Schneider Electric USA.
 - 2. Comply with requirements of utility company for meter center.
 - a. Comply with UL 67.
 - 3. Housing: UL 50E, Type 1 enclosure.
 - 4. Meter Socket Rating: Coordinated with connected feeder circuit rating.
 - 5. Minimum Short-Circuit Rating: 22 000 A symmetrical at rated voltage.
 - 6. Steady-state and short-circuit current ratings must have ratings that match connected circuit ratings.
 - 7. Main Disconnect Device:
 - a. Circuit breaker, series-combination rated for use with downstream feeder and branch circuit breakers and having adjustable magnetic trip setting for circuit-breaker frame sizes of 250 A and larger. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers." Circuit breakers must be operable from outside enclosure to disconnect unit. Configure cover so it can be opened only when disconnect switch is open.
 - b. Fusible switch, UL 98 Type GD, series-combination rated by fuse manufacturer to protect downstream feeder and branch circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers." Switch must be operable from outside enclosure to disconnect unit. Configure cover so that it can be opened only when disconnect switch is open.

8. Feeder Circuit Breakers: Series-combination-rated molded-case units, rated to protect downstream circuit breakers and to house load centers and panelboards that have 10 000 A interrupting capacity.
 - a. Identification: Complying with requirements in Section 260553 "Identification for Electrical Systems."
 - b. Physical Protection: Tamper resistant, with hasp for padlock.
9. Surge Protection:
 - a. Factory-installed in main disconnect, integrally mounted, UL 1449 Type 1. Comply with Section 264313 "Surge Protection Devices."
 - b. Field-mounted external to main disconnect, UL 1449 Type 2, with integral disconnect and overcurrent protective device. Comply with Section 264313 "Surge Protection Devices."
 - c. Factory-installed in main terminal box, integrally mounted, UL 1449 Type 1. Comply with Section 264313 "Surge Protection Devices."
 - d. Field-mounted external to main terminal box, UL 1449 Type 2, with integral disconnect and overcurrent protective device. Comply with Section 264313 "Surge Protection Devices."

F. Arc-Flash Warning Labels;

1. Comply with requirements for "Arc-Flash Warning Labels" in Section 260573.19 "Arc-Flash Studies." Apply 3-1/2-by-5 inch thermal transfer label of high-adhesion polyester for each work location included in the analysis.
2. Comply with requirements for "Self-Adhesive Equipment Labels" and "Signs" in Section 260553 "Identification for Electrical Systems." Apply 3-1/2-by-5 inch thermal transfer label of high-adhesion polyester for each work location included in the analysis. Labels must be machine printed, with no field-applied markings.
 - a. Label must have orange header with wording, "WARNING, ARC-FLASH HAZARD," and must include the following information taken directly from arc-flash hazard analysis:
 - 1) Location designation.
 - 2) Nominal voltage.
 - 3) Flash protection boundary.
 - 4) Hazard risk category.
 - 5) Incident energy.
 - 6) Working distance.
 - 7) Engineering report number, revision number, and issue date.

2.3 ELECTRICITY METERS

- A. System Description: Able to meter designated activity loads, with or without external alarm, control, and communication capabilities, or other optional features.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Davidge Controls.
 2. Eaton.

3. SATEC
4. E-Mon D-Mon.
5. Leviton Manufacturing Co., Inc.
6. National Meter Industries.
7. Sensus Metering Systems.
8. Siemens Industry, Inc., Energy Management Division.
9. Square D; Schneider Electric USA.

C. General Requirements for Meters:

1. Comply with NEMA ANSI C12.1 and NEMA ANSI C12.20, **[0.1] [0.2] [0.5]** accuracy class.
2. Ambient Temperature: Minus 22 deg F to plus 158 deg F.
3. Humidity: Zero to 95 percent, noncondensing.
4. Capacities and Characteristics:
 - a. Circuit: 120/240 V(ac), 100 A.
 - b. Measure: kWh, onboard LED display.
 - c. Remote-Reading Options: None.
5. Billing Meters Accuracy: **[0.2] [0.5] [1.0]** percent of reading, complying with NEMA ANSI C12.20.
6. Meters Certification: Certified by **[California Type Evaluation Program]** <Insert agency> as complying with **[4 CCR 4027, Article 2.2]** <Insert state or Federal regulatory requirement>.
7. Certify that meters comply with NEMA ANSI C12.20 requirements by laboratory accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology (NIST). Laboratory must use test equipment that is certified annually and is traceable to NIST standards.
8. Enclosure: Supplied by meter manufacturer, UL 50E, **[Type 1] [Type 3R] [Type 4X]** minimum, with provisions for locking or sealing.
9. Identification: Comply with requirements in Section 260553 "Identification for Electrical Systems."
10. Onboard Nonvolatile Data Storage: kWh, until reset.
11. Sensors: Current-sensing type, supplied by electronic meter manufacturer, with current or voltage output, selected for optimum range and accuracy for meters indicated for this application.
 - a. Type: **[Split] [and] [solid]** core, complying with recommendation of meter manufacturer.

D. kWh Meter: Electronic **[single-phase] [and] [three-phase]** meters, measuring electricity use.

1. Voltage and Phase Configuration: Meter must be designed for use on circuits with voltage rating and phase configuration indicated for its application.
2. Display:
 - a. LCD with characters not less than 0.25 inch high, indicating accumulative kWh and current kilowatt load. Retain accumulated kWh in nonvolatile memory, until reset.
 - b. Digital electromechanical counter, indicating accumulative kWh.

E. kWhd Meter: Electronic **[single-phase] [and] [three-phase]** meters, measuring electricity use and demand. Demand must be integrated over **[15-minute]** <Insert time> interval.

1. Voltage and Phase Configuration: Meter must be designed for use on circuits with voltage rating and phase configuration indicated for its application.
 2. Display: LCD with characters not less than 0.25 inch high, indicating the following:
 - a. Accumulative kWh.
 - b. Current time and date.
 - c. Current demand.
 - d. Historic peak demand.
 - e. Time and date of historic peak demand.
 3. Retain accumulated kWh and historic peak demand in nonvolatile memory, until reset.
- F. KY and KYZ Pulse Totalizer:
1. Pulse Totalizer: Instrument for demand and billing applications where one or more utility revenue meters stream KY or KYZ energy pulses. Instrument must totalize kWh accumulated over user-selected period and must log maximum and minimum kWhd for that period. Record each period with date/time stamp. Time period must be user selected from one to 60 minutes.
 - a. Pulse Input: **[One] <Insert number>**, individually programmable, KYZ Form C (three-wire) contact pulse channels. Pulse interval, pulse rate, and minimum pulse width must be field adjustable, set for pulse stream provided by utility revenue meter.
 - b. Data Totalizing Capacity of Each Channel: Not less than 149 days at 15-minute intervals.
 - c. Instrument Power: User selectable, 120 V(ac) and 277 V(ac).
 - d. Clock: Line frequency.
- G. Remote Reading Options:
1. Pulse Output: **[KY] [KYZ]**, complete with optical sensor and interface devices.
 2. TIA-232 serial interface.
 3. TIA-485 serial interface, with **[Modbus RTU protocol]**.
 4. USB interface.
 5. TCP/IP adapter.
- H. Current-Transformer Cabinet: Size and configuration as recommended by metering equipment manufacturer for use with indicated connected feeder and sensors.
- I. Uninterruptible Power Supply: Single phase, 120 V(ac), sized and rated to provide continuous power to meter for operations of **[48]** hours after interruption of normal power.
1. Output: Sine wave, total harmonic distortion less than 5 percent at full load.
 2. Battery: Maintenance free, sealed, lead acid, and leakproof.
 3. Control Panel: LED status display of "on-battery," "replace battery," and "overload."
- J. Data Transmission Cable: Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."
- K. Software: PC-based product **[of] [recommended by]** meter manufacturer, suitable for calculating utility cost allocation.

1. Utility Cost Allocation: Automatically import electricity-usage records to allocate electricity costs for the following:
 - a. At least [15] <Insert number> departments.
 - b. At least [30] <Insert number> tenants or activities.
 - c. At least [five] <Insert number> processes.
 - d. At least [five] <Insert number> buildings.
 - e. <Insert entity>.
2. Activity Billing Software: Automatically import electricity-usage records to automatically compute and prepare electricity-use statements[**and invoices**] based on electricity use[**and peak demand**]. Maintain separate directory for each allocation. Prepare summary reports in user-defined formats and time intervals.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with manufacturer's published instructions.
- B. Reference Standards:
 1. Install modular meter center according to switchboard installation requirements in NECA 400.
 2. Install arc-flash labels as required by NFPA 70.
- C. Special Techniques:
 1. Install meters furnished by utility company. Install raceways and equipment according to utility company's published instructions. Provide empty conduits for metering leads and extend grounding connections as required by utility company.
 2. Wiring Methods:
 - a. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 - b. Install unshielded, twisted-pair cable for control and signal transmission conductors, complying with Section 271513 "Communications Copper Horizontal Cabling."
 - c. Minimum conduit size is metric designator 16 (trade size 1/2).

3.2 IDENTIFICATION

- A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 1. Series Combination Warning Label: Self-adhesive labels, with text as required by NFPA 70.
 2. Equipment Identification Labels: Self-adhesive labels with clear protective overlay. For residential meters, provide additional card holder suitable for [**printed, weather-resistant card**] [**typewritten card**] with occupant's name.

3.3 FIELD QUALITY CONTROL

A. **[Acceptance]** Testing Preparation:

1. **<Insert requirements>**.

B. Field tests and inspections must be witnessed by **[Architect]** **[Tenant]** **[authorities having jurisdiction]** **<Insert names or titles of witnesses>**.

C. Tests and Inspections:

1. Equipment and Software Setup:

- a. Set meter date and time clock.
- b. Test, calibrate, and connect pulse metering system.
- c. Set and verify billing demand interval for demand meters.
- d. Report settings and calibration results.
- e. Set up reporting and billing software, insert billing location names and initial constant values and variable needed for billing computations.

2. Connect load of known power rating, **[1.5 kW]** **<Insert kilowatts>** minimum, to circuit supplied by metered feeder.
3. Turn off circuits supplied by metered feeder and secure them in off condition.
4. Run test load continuously for eight hours minimum, or longer, to obtain measurable meter indication. Use test-load placement and setting that ensures continuous, safe operation.
5. Check and record meter reading at end of test period and compare with actual electricity used, based on test-load rating, duration of test, and sample measurements of supply voltage at test-load connection. Record test results.
6. Generate test report and billing for each tenant or activity from meter reading tests.

D. Nonconforming Work:

1. Electricity metering will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

E. Collect, assemble, and submit test and inspection reports.

F. Manufacturer Services:

1. Engage factory-authorized service representative to **[support]** **[supervise]** field tests and inspections.

3.4 PROTECTION

- A. After installation, protect metering equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.5 MAINTENANCE

- A. Software and Firmware Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software and firmware support for **[two] <Insert number>** years.
2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software and firmware upgrades that become available within **[two] <Insert number>** years from date of Substantial Completion.**[Verify that upgrading software includes operating system and new or revised licenses for using software.]**
 - a. Upgrade Notice: No fewer than **[30] <Insert number>** days to allow Owner to schedule and access the system**[and to upgrade computer equipment if necessary.]**
3. Upgrade Reports: Prepare report after each update, documenting upgrades installed.

END OF SECTION

SECTION 262726

WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Standard-grade receptacles, 125 V, 20 A.
 - 2. USB receptacles.
 - 3. GFCI receptacles, 125 V, 20 A.
 - 4. SPD receptacles, 125 V, 20 A.
 - 5. Decorator-style devices, 20 A.
 - 6. Occupancy sensors.
 - 7. Wall plates.
 - 8. Floor service fittings.

1.3 DEFINITIONS

- A. AFCI: Arc-fault circuit interrupter.
- B. BAS: Building automation system.
- C. GFCI: Ground-fault circuit interrupter.
- D. SPD: Surge protective device.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.
- C. Samples: One for each type of device and wall plate specified, in each color specified.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 GENERAL WIRING-DEVICE REQUIREMENTS

- A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- B. Comply with NFPA 70.
- C. RoHS compliant.
- D. Comply with NEMA WD 1.
- E. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:
 - 1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
 - 2. Devices shall comply with requirements in this Section.
- F. Devices for Owner-Furnished Equipment:
 - 1. Receptacles: Match plug configurations.
- G. Device Color:
 - 1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
- H. Wall Plate Color: For plastic covers, match device color.
- I. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 STANDARD-GRADE RECEPTACLES, 125 V, 20 A

- A. Isolated-Ground Duplex Receptacles, 125 V, 20 A:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Eaton (Wiring Devices - Arrow Hart).
 - b. Hubbell Incorporated (Wiring Device-Kellems).
 - c. Legrand North America, LLC (Pass & Seymour).
 - d. Leviton Manufacturing Co., Inc.
 - 2. Description: Straight blade; equipment grounding contacts shall be connected only to green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts. Two pole, three wire, and self-grounding.
 - 3. Configuration: NEMA WD 6, Configuration 5-20R.
 - 4. Standards: Comply with UL 498 and FS W-C-596.
- B. All devices shall be Tamper-Resistant Duplex Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Eaton (Wiring Devices - Arrow Hart).
 - b. Hubbell Incorporated (Wiring Device-Kellems).
 - c. Legrand North America, LLC (Pass & Seymour).
 - d. Leviton Manufacturing Co., Inc.
2. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Standards: Comply with UL 498 and FS W-C-596.
5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.

C. Tamper- and Weather-Resistant Duplex Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Eaton (Wiring Devices - Arrow Hart).
 - b. Hubbell Incorporated (Wiring Device-Kellems).
 - c. Legrand North America, LLC (Pass & Seymour).
 - d. Leviton Manufacturing Co., Inc.
2. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Standards: Comply with UL 498.
5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

D. Controlled Receptacles:

1. All receptacles shown as "switched" or "controlled" on the plans shall be provided with the word "CONTROLLED" etched on the face of the receptacle to indicate its use.

2.3 STANDARD-GRADE RECEPTACLES, 125 V, 20 A

A. Isolated-Ground Duplex Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Eaton (Wiring Devices - Arrow Hart).
 - b. Hubbell Incorporated (Wiring Device-Kellems).
 - c. Legrand North America, LLC (Pass & Seymour).
 - d. Leviton Manufacturing Co., Inc.
2. Description: Straight blade; equipment grounding contacts shall be connected only to green grounding screw terminal of the device and with inherent electrical isolation from

mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts. Two pole, three wire, and self-grounding.

3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Standards: Comply with UL 498 and FS W-C-596.

2.4 USB RECEPTACLES

A. USB Charging Receptacles:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Eaton (Wiring Devices - Arrow Hart).
 - b. Hubbell Incorporated (Wiring Device-Kellems).
 - c. Legrand North America, LLC (Pass & Seymour).
 - d. Leviton Manufacturing Co., Inc.
2. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap.
3. USB Receptacles: Dual and quad, USB Type A, 5 V dc, and 2.1 A per receptacle (minimum).
4. Standards: Comply with UL 1310 and USB 3.0 devices.

2.5 GFCI RECEPTACLES, 125 V, 20 A

A. Duplex GFCI Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Eaton (Wiring Devices - Arrow Hart).
 - b. Hubbell Incorporated (Wiring Device-Kellems).
 - c. Legrand North America, LLC (Pass & Seymour).
 - d. Leviton Manufacturing Co., Inc.
2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Type: Feed.
5. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.

2.6 SPD RECEPTACLES, 125 V, 20 A

A. Duplex SPD Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Eaton (Wiring Devices - Arrow Hart).
 - b. Hubbell Incorporated (Wiring Device-Kellems).
 - c. Legrand North America, LLC (Pass & Seymour).
 - d. Leviton Manufacturing Co., Inc.

2. Grounding: Equipment grounding contacts shall be connected only to green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.7 CORD AND PLUG SETS

- A. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
- B. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
- C. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.8 TOGGLE SWITCHES, 120/277 V, 20 A

- A. Single-Pole Switches, 120/277 V, 20 A:
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Eaton (Wiring Devices - Arrow Hart).
 - b. Hubbell Incorporated (Wiring Device-Kellems).
 - c. Legrand North America, LLC (Pass & Seymour).
 - d. Leviton Manufacturing Co., Inc.
 2. Standards: Comply with UL 20 and FS W-S-896.

2.9 DECORATOR-STYLE DEVICES, 20 A

- A. Decorator Tamper-Resistant Duplex Receptacles, 125 V, 20 A:
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Eaton (Wiring Devices - Arrow Hart).
 - b. Hubbell Incorporated (Wiring Device-Kellems).
 - c. Legrand North America, LLC (Pass & Seymour).
 - d. Leviton Manufacturing Co., Inc.
 2. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
 3. Configuration: NEMA WD 6, Configuration 5-20R.
 4. Standards: Comply with UL 498.
 5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.
- B. Decorator, Tamper- and Weather-Resistant, Duplex Receptacles, 125 V, 20 A:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Eaton (Wiring Devices - Arrow Hart).
 - b. Hubbell Incorporated (Wiring Device-Kellems).
 - c. Legrand North America, LLC (Pass & Seymour).
 - d. Leviton Manufacturing Co., Inc.
2. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Standards: Comply with UL 498.
5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

2.10 WALL PLATES

- A. Single Source: Obtain wall plates from same manufacturer of wiring devices. For all front-of-house spaces, wall plates shall be such that screws are not visible.
- B. Single and combination types shall match corresponding wiring devices.
 1. Plate-Securing Screws: Metal with head color to match plate finish. Screws shall not be visible for all front-of-house wall plates.
 2. Material for Finished Spaces: Smooth, high-impact thermoplastic 0.035-inch-thick, satin-finished.
 3. Material for Unfinished Spaces: Smooth, high-impact thermoplastic.
 4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover and listed and labeled for use in wet and damp locations.
- C. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.
- D. Antimicrobial Cover Plates:
 1. Contact surfaces treated with a coating that kills 99.9 percent of certain common bacteria within two hours when regularly and properly cleaned.
 2. Tarnish resistant.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B. Coordination with Other Trades:
 1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.

2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall comply with NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
 - a. Cut back and pigtail or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pig tailing existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles [up] [down], and on horizontally mounted receptacles to the [right] [left].
2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

- H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.
- I. All receptacles shall be provided with panel and circuit label fixed to the device's wall plate.

3.2 GFCI RECEPTACLES

- A. Install non-feed-through GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

- A. Comply with Section 260553 "Identification for Electrical Systems."
- B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with [black] [white] [red]-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.
- C. Essential Electrical System: Mark receptacles supplied from the essential electrical system to allow easy identification using a self-adhesive label.

3.4 FIELD QUALITY CONTROL

- A. Test Instruments: Use instruments that comply with UL 1436.
- B. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
- C. Perform the following tests and inspections[with the assistance of a factory-authorized service representative]:
 - 1. Test Instruments: Use instruments that comply with UL 1436.
 - 2. Test Instrument for Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
- D. Tests for Receptacles:
 - 1. Line Voltage: Acceptable range is 105 to 132 V.
 - 2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
 - 3. Ground Impedance: Values of up to 2 ohms are acceptable.
 - 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
 - 5. Using the test plug, verify that the device and its outlet box are securely mounted.
 - 6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault-current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
- E. Test straight-blade [convenience outlets in patient-care areas] [hospital-grade outlets] for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz.
- F. Wiring device will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.

END OF SECTION

SECTION 262816

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Fusible switches.
 - 2. Non-fusible switches.
 - 3. Receptacle switches.
 - 4. Shunt trip switches.
 - 5. Molded-case circuit breakers (MCCBs).
 - 6. Molded-case switches.
 - 7. Enclosures.

1.3 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include nameplate ratings, dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.
 - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
 - 4. Include evidence of a nationally recognized testing laboratory (NRTL) listing for series rating of installed devices.
 - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
 - 6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in [PDF] [and] <Insert calculation program format> electronic format.
- B. Shop Drawings: For enclosed switches and circuit breakers.

1. Include plans, elevations, sections, details, and attachments to other work.
2. Include wiring diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Seismic Qualification Data: Certificates, for enclosed switches and circuit breakers, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.
 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
 - b. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Provide in PDF and electronic format.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Fuses: Equal to [10] <Insert number> percent of quantity installed for each size and type, but no fewer than [three] <Insert number> of each size and type.
 2. Fuse Pullers: [Two] <Insert number> for each size and type.

1.8 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.
 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.9 FIELD CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

1.10 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified[and the unit will be fully operational after the seismic event]."

2.2 GENERAL REQUIREMENTS

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with NFPA 70.

2.3 FUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. ABB (Electrification Products Division).
 2. Eaton.
 3. Schneider Electric USA (Square D).
 4. Siemens Industry, Inc., Energy Management Division.
- B. Type HD, Heavy Duty:
 1. Single or Double throw.
 2. Three or six pole.
 3. 600-V ac.
 4. 200 A and smaller.

5. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses.
6. Lockable handle with capability to accept three padlocks and interlocked with cover in closed position.

C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 24-V ac.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Compression type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

2.4 NONFUSIBLE SWITCHES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. ABB (Electrification Products Division).
2. Eaton.
3. Schneider Electric USA (Square D).
4. Siemens Industry, Inc., Energy Management Division.

B. Type HD, Heavy Duty, Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

C. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

D. Type HD, Heavy Duty, Three Pole, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

E. Accessories:

1. Conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Isolated Ground Kit: Internally mounted; insulated, labeled for copper and aluminum neutral conductors.
4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 24-V ac.

6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Compression type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

2.5 MOLDED-CASE CIRCUIT BREAKERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. ABB (Electrification Products Division).
 2. Eaton.
 3. NOARK Electric North America.
 4. Schneider Electric USA (Square D).
 5. Siemens Industry, Inc., Energy Management Division.
- B. Circuit breakers shall be constructed using glass-reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.
- C. Circuit breakers shall have a toggle operating mechanism with common tripping of all poles, which provides quick-make, quick-break contact action. The circuit-breaker handle shall be over center, be trip free, and reside in a tripped position between on and off to provide local trip indication. Circuit-breaker escutcheon shall be clearly marked on and off in addition to providing international I/O markings. Equip circuit breaker with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit-breaker tripping mechanism for maintenance and testing purposes.
- D. The maximum ampere rating and UL, IEC, or other certification standards with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker. Circuit breakers shall be 100 percent rated shall be listed by UL as recognized component combinations. Any series rated combination used shall be marked on the end-use equipment along with the statement "Caution - Series Rated System. _____ Amps Available. Identical Replacement Component Required."
- E. MCCBs shall be equipped with a device for locking in the isolated position.
- F. Lugs shall be suitable for 140 deg F rated wire on 125-A circuit breakers and below.
- G. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.
- H. Thermal-Magnetic Circuit Breakers: Inverse time-current thermal element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- I. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
- J. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
 1. Instantaneous trip.
 2. Long- and short-time pickup levels.
 3. Long- and short-time time adjustments.
 4. Ground-fault pickup level, time delay, and I-squared t response.

- K. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
- L. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).
- M. Features and Accessories:
 - 1. Standard frame sizes, trip ratings, and number of poles.
 - 2. Lugs: Compression type, suitable for number, size, trip ratings, and conductor material.
 - 3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
 - 4. Ground-Fault Protection: Comply with UL 1053; [integrally mounted, self-powered] [remote-mounted and powered] type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
 - 5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
 - 6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.

2.6 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
- B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel NEMA 250 Type 1.
- C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.
- D. Operating Mechanism: The circuit-breaker operating handle shall be [externally operable with the operating mechanism being an integral part of the box, not the cover] [directly operable through the front cover of the enclosure (NEMA 250 Type 1)] [directly operable through the dead front trim of the enclosure (NEMA 250 Type 3R)] [externally operable with the operating mechanism being an integral part of the cover (NEMA 250 Types 7, 9)]. The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

1. Commencement of work shall indicate Installer's acceptance of the areas and conditions as satisfactory.

3.2 PREPARATION

- A. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 1. Notify Architect no fewer than seven days in advance of proposed interruption of electric service.
 2. Indicate method of providing temporary electric service.
 3. Do not proceed with interruption of electric service without Owner's written permission.
 4. Comply with NFPA 70E.

3.3 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

- A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.
 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 2. Outdoor Locations: NEMA 250, Type 3R.
 3. [Kitchen] [Wash-Down] Areas: NEMA 250, Type 4X.

3.4 INSTALLATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- E. Install fuses in fusible devices.
- F. Comply with NFPA 70 and NECA 1.

3.5 IDENTIFICATION

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections with the assistance of a factory-authorized service representative].
- E. Tests and Inspections for Switches:
 - 1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, grounding, and clearances.
 - c. Verify that the unit is clean.
 - d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
 - e. Verify that fuse sizes and types match the Specifications and Drawings.
 - f. Verify that each fuse has adequate mechanical support and contact integrity.
 - g. Inspect bolted electrical connections for high resistance using one of the two following methods:
 - 1) Use a low-resistance ohmmeter.
 - a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
 - a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
 - h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
 - i. Verify correct phase barrier installation.
 - j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.
 - 2. Electrical Tests:
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
 - b. Measure contact resistance across each switchblade fuse holder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
 - c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of

manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.

- d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.
- e. Perform ground fault test according to NETA ATS 7.14 "Ground Fault Protection Systems, Low-Voltage."

F. Tests and Inspections for Molded Case Circuit Breakers:

1. Visual and Mechanical Inspection:

- a. Verify that equipment nameplate data are as described in the Specifications and shown on the Drawings.
- b. Inspect physical and mechanical condition.
- c. Inspect anchorage, alignment, grounding, and clearances.
- d. Verify that the unit is clean.
- e. Operate the circuit breaker to ensure smooth operation.
- f. Inspect bolted electrical connections for high resistance using one of the two following methods:
 - 1) Use a low-resistance ohmmeter.
 - a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
 - a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.
- g. Inspect operating mechanism, contacts, and chutes in unsealed units.
- h. Perform adjustments for final protective device settings in accordance with the coordination study.

2. Electrical Tests:

- a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
- b. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with circuit breaker closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
- c. Perform a contact/pole resistance test. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not

- available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
- d. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid state components, follow manufacturer's recommendation. Insulation resistance values shall be no less than two megohms.
 - e. Determine the following by primary current injection:
 - 1) Long-time pickup and delay. Pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
 - 2) Short-time pickup and delay. Short-time pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
 - 3) Ground-fault pickup and time delay. Ground-fault pickup values shall be as specified. Trip characteristics shall not exceed manufacturer's published time-current characteristic tolerance band, including adjustment factors.
 - 4) Instantaneous pickup. Instantaneous pickup values shall be as specified and within manufacturer's published tolerances.
 - f. Test functionality of the trip unit by means of primary current injection. Pickup values and trip characteristics shall be as specified and within manufacturer's published tolerances.
 - g. Perform minimum pickup voltage tests on shunt trip and close coils in accordance with manufacturer's published data. Minimum pickup voltage of the shunt trip and close coils shall be as indicated by manufacturer.
 - h. Verify correct operation of auxiliary features such as trip and pickup indicators; zone interlocking; electrical close and trip operation; trip-free, anti-pump function; and trip unit battery condition. Reset all trip logs and indicators. Investigate units that do not function as designed.
 - i. Verify operation of charging mechanism. Investigate units that do not function as designed.
- 3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 4. Perform the following infrared scan tests and inspections and prepare reports:
 - 5.
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Substantial Completion.
 - c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- G. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

H. Prepare test and inspection reports.

1. Test procedures used.
2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
3. List deficiencies detected, remedial action taken, and observations after remedial action.

3.7 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

END OF SECTION

SECTION 263600
TRANSFER SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes automatic transfer switches rated 600 V and less.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
 - 2. Single-Line Diagram: Show connections between transfer switch, power sources, and load.

1.3 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Data: Certificates, for transfer switches, accessories, and components, from manufacturer.
- B. Source quality control reports.
- C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NEMA ICS 1.

- C. Comply with NFPA 110.
- D. Comply with UL 1008 unless requirements of these Specifications are stricter.
- E. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
- F. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
 - 1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
 - 2. Short-time withstand capability for 30 cycles.
- G. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- H. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- I. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.
- J. Service-Rated Transfer Switch:
 - 1. Comply with UL 869A and UL 489.
 - 2. Provide terminals for bonding the grounding electrode conductor to the grounded service conductor.
 - 3. In systems with a neutral, the bonding connection shall be on the neutral bus.
 - 4. Provide removable link for temporary separation of the service and load grounded conductors.
 - 5. Surge Protective Device: Service rated.
 - 6. Ground-Fault Protection: Comply with UL 1008 for normal bus
 - 7. Service Disconnecting Means: Externally operated, manual mechanically actuated.
- K. Neutral Switching: Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.
- L. Neutral Terminal: Solid and fully rated unless otherwise indicated.
- M. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.
 - 1. Ammeter to display charging current.
 - 2. Fused ac inputs and dc outputs.
- N. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable with printed markers at terminations.

Color-coding and wire and cable markers are specified in Section 260553 "Identification for Electrical Systems."

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
4. Accessible via front access.

- O. Enclosures: General-purpose NEMA 250, Type 1 complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.2 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Automatic Switch Co.
2. Russelectric Co.

- B. Comply with Level 1 equipment according to NFPA 110.

- C. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable.
2. Switch Action: Double throw; mechanically held in both directions.
3. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
4. Conductor Connectors: Suitable for use with conductor material and sizes.
5. Material: Hard-drawn copper, 98 percent conductivity.
6. Main and Neutral Lugs: Compression type.
7. Ground Lugs and Bus-Configured Terminators: Compression type.

- D. Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.

1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

- E. Automatic Transfer-Switch Controller Features:

1. Controller operates through a period of loss of control power.
2. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.

4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
 5. Test Switch: Simulate normal-source failure.
 6. Switch-Position Pilot Lights: Indicate source to which load is connected.
 7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
 - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 - b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
 8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
 9. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
 10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
 11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
 12. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
 13. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
 - a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
 - b. Push-button programming control with digital display of settings.
 - c. Integral battery operation of time switch when normal control power is unavailable.
- F. Large-Motor-Load Power Transfer:
1. Programmed Neutral Switch Position: Switch operator with programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Adjustable pause from 0.5 to 30 seconds minimum, and factory set for 0.5 second unless otherwise indicated. Time delay occurs for both transfer directions. Disable pause unless both sources are live.

2.3 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.
- B. Prepare test and inspection reports.
 1. For each of the tests required by UL 1008, performed on representative devices, for systems. Include results of test for the following conditions:

- a. Overvoltage.
- b. Undervoltage.
- c. Loss of supply voltage.
- d. Reduction of supply voltage.
- e. Alternative supply voltage or frequency is at minimum acceptable values.
- f. Temperature rise.
- g. Dielectric voltage-withstand; before and after short-circuit test.
- h. Overload.
- i. Contact opening.
- j. Endurance.
- k. Short circuit.
- l. Short-time current capability.
- m. Receptacle withstand capability.
- n. Insulating base and supports damage.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Floor-Mounting Switch: Anchor to floor by bolting.
 - 1. Install transfer switches on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
 - 3. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.
 - 4. Provide workspace and clearances required by NFPA 70.
- B. Annunciator and Control Panel Mounting: Flush in wall unless otherwise indicated.
- C. Identify components according to Section 260553 "Identification for Electrical Systems."
- D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.
- E. Comply with NECA 1.

3.2 CONNECTIONS

- A. Wiring Method: Install cables in raceways and cable trays except within electrical enclosures. Conceal raceway and cables except in unfinished spaces.
 - 1. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
- C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Connect twisted pair cable according to Section 260523 "Control-Voltage Electrical Power Cables."

- E. Connect twisted pair cable according to Section 271513 "Communications Copper Horizontal Cabling."
- F. Route and brace conductors according to manufacturer's written instructions and Section 260529 "Hangers and Supports for Electrical Systems." Do not obscure manufacturer's markings and labels.
- G. Brace and support equipment according to Section 260548.16 "Seismic Controls for Electrical Systems."
- H. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches (457 mm) in length.

3.3 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

- 1. Visual and Mechanical Inspection:

- a. Compare equipment nameplate data with Drawings and Specifications.
- b. Inspect physical and mechanical condition.
- c. Inspect anchorage, alignment, grounding, and required clearances.
- d. Verify that the unit is clean.
- e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
- f. Verify that manual transfer warnings are attached and visible.
- g. Verify tightness of all control connections.
- h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.
- i. Perform manual transfer operation.
- j. Verify positive mechanical interlocking between normal and alternate sources.
- k. Perform visual and mechanical inspection of surge arresters.
- l. Inspect control power transformers.
 - 1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
 - 2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
 - 3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.

- 2. Electrical Tests:

- a. Perform insulation-resistance tests on all control wiring with respect to ground.
- b. Perform a contact/pole-resistance test. Compare measured values with manufacturer's acceptable values.
- c. Verify settings and operation of control devices.
- d. Calibrate and set all relays and timers.

- e. Verify phase rotation, phasing, and synchronized operation.
 - f. Perform automatic transfer tests.
 - g. Verify correct operation and timing of the following functions:
 - 1) Normal source voltage-sensing and frequency-sensing relays.
 - 2) Engine start sequence.
 - 3) Time delay on transfer.
 - 4) Alternative source voltage-sensing and frequency-sensing relays.
 - 5) Automatic transfer operation.
 - 6) Interlocks and limit switch function.
 - 7) Time delay and retransfer on normal power restoration.
 - 8) Engine cool-down and shutdown feature.
3. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
- a. Check for electrical continuity of circuits and for short circuits.
 - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - c. Verify that manual transfer warnings are properly placed.
 - d. Perform manual transfer operation.
4. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and demonstrate interlocking sequence and operational function for each switch at least three times.
- a. Simulate power failures of normal source to automatic transfer switches and retransfer from emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
- a. Verify grounding connections and locations and ratings of sensors.
- B. Coordinate tests with tests of generator and run them concurrently.
- C. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- D. Transfer switches will be considered defective if they do not pass tests and inspections.
- E. Remove and replace malfunctioning units and retest as specified above.
- F. Prepare test and inspection reports.

- G. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.
1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
 3. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.
- B. Training shall include testing ground-fault protective devices and instructions to determine when the ground-fault system shall be retested. Include instructions on where ground-fault sensors are located and how to avoid negating the ground-fault protection scheme during testing and circuit modifications.
- C. Coordinate this training with that for generator equipment.

END OF SECTION

SECTION 264113

LIGHTNING PROTECTION SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

- A. This Section specifies the lightning protection and grounding system for the building(s) or structure(s). This system provides facility protection for the building and occupants by preventing damage to the structure caused by lightning and induced transient currents. The design of this system shall be in strict accordance with this section of the specification and all Contract Documents that apply.
- B. The work covered under this section of the specifications consists of furnishing labor, materials and engineering services required for the completion of a functional and unobtrusive lightning protection and facility grounding system.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 STANDARDS

- A. Except as modified by governing codes and by the Contract Documents, comply with the latest provisions and latest recommendations of the following:
 - 1. Underwriters' Laboratories Master Label Code 96 and 96A.
 - 2. NFPA 780.
 - 3. Lightning Protection Installation Standard LPI-175.
 - 4. National Electrical Code – NFPA 70 (NEC)

1.4 QUALITY ASSURANCE

- A. The contractor shall furnish a UL Certificate upon completion of the installation.
- B. The System Design shall be completed, and the shop drawing stamped by an LPI Certified Master Designer - Installer of Lightning Protection Systems.
- C. The installing contractor shall be listed with the Lightning Protection Institute and Underwriters' Laboratories, Inc.
- D. The installation contractor shall have personnel on staff Certified by the LPI as a Master Installer – Designer of lightning protection systems. LPI qualified staff, Journeyman or higher, shall provide on-site supervision of the installation to the Standards.

1.5 COORDINATION

- A. Ensure that the installation, including air terminals, do not conflict with the operation of other rooftop systems. Where required, provide alternate components such as spring mounted air terminals to accomplish this coordination, at no additional cost.

- B. Coordinate location of all ground inspection wells with the Architect/Engineer.
- C. Coordinate location of Master Label mounting with the Architect/Engineer prior to installation.

1.6 ACTION SUBMITTALS

- A. Product Data: For each type of product
- B. Shop Drawings:
 - 1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
 - 2. Include raceway locations needed for the installation of conductors.
 - 3. Details of air terminals, ground rods or plates, ground rings, conductor supports, splices, and terminations, including concealment requirements.
 - 4. Include roof attachment details, coordinated with the roof installation.
 - 5. Calculations required by NFPA 780 for bonding of metal bodies.
- C. Coordination Drawings: Lightning protection system shop drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
 - 1. Lightning protection cabling attachments to roofing systems and accessories.
 - 2. Lightning protection strike termination device attachment to roofing systems, coordinated with the roofing system manufacturer.
 - 3. Lightning protection system components penetrating roofing and moisture protection systems and system components, coordinated with the roofing system manufacturer.

PART 2 - PRODUCTS

2.1 STANDARDS

- A. All materials shall comply in weight, size, and composition with the requirements of the UL 96 Materials Standards. All equipment shall be UL listed and properly labeled. The system furnished under this specification shall be the standard product of a manufacturer regularly engaged in the production of lightning protection equipment and a member of LPI. Equipment shall be the manufacturer's latest approved design of construction to suit the application where it shall be used in accordance with accepted industry standards and with NFPA, LPI, & UL requirements.
- B. Surge Suppression products for the electrical service entrance shall comply with both NFPA 780 Sec 4.20 and UL 1449 4th Edition. Surge Suppression products for the communication service shall meet NFPA 780 Sec 4.20.

2.2 ACCEPTABLE MANUFACTURERS

- A. Heary Brothers.
- B. Approved Lightning Protection Co.
- C. Erico.
- D. AC Lightning Security.

- E. Harger Lightning Protection Co.
- F. ABB / Furse Installation Products
- G. Lyncole
- H. VFC ZPen®

2.3 TYPE OF SYSTEM

- A. Install all conductors and complementary parts in a concealed manner so the completed work is unobtrusive and does not detract from the appearance of the structure.
- B. All areas of flat roofs shall be cross run with the same size conductor cable so that no area larger than 50 feet by 150 feet remains unprotected. Mount points on cast copper bronze point bases and cable clips to the finished roof to avoid any roof penetrations.
- C. All materials shall be copper. Aluminum shall be used on surface materials incompatible with copper.

2.4 AIR TERMINALS

- A. Air terminals shall be 3/8" x 12" solid copper nickel tipped and shall extend at least 10 inches above the object to be protected. All air terminal bases shall be cast bronze with stainless steel bolt-pressure cable connectors. The air terminals shall be spaced so as not to exceed 20' apart around the outside perimeter of the roof or the ridge and not over 50 square feet apart through the center of flat roof areas. All air terminal bases shall be equipped with bolt pressure cable connections and be securely mounted with stainless steel screws or bolts. Air terminals shall be located within 18" of roof edges and outside corners of protected areas.

2.5 CONDUCTORS

- A. Conductors shall consist of a U.L. listed #4/0 AWG with 28 strands of 14 gauge copper wire weighing 375 lbs. per 1000 feet and installed in accordance with the U.L. requirements. A perimeter conductor shall be installed around the entire main roof, and all penthouses and rooftop mechanical and electrical equipment. Each perimeter conductor shall be connected to at least two (2) down leads, providing a two (2) way path to ground from each air terminal. All center roof air terminals shall be interconnected with conductors to the outside perimeter conductor. Conductors on the flat roof areas shall be run exposed. Ground connections shall be made around the perimeter of each roof and to the main down conductor at a maximum of 100'-0" on centers.
- B. Utilize conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

2.6 CONNECTORS AND FASTENERS

- A. Use approved connectors of proper electrical and mechanical characteristics. Use only approved exothermic welded connections for all conductor splices and connections.
- B. Rigidly and permanently attach conductors and air terminals to the building with fasteners of proper strength and design.
- C. Fasteners shall be spaced not to exceed 3'-0" centers.

- D. All fasteners shall be provided with appropriate loop supports. No support penetrations shall be made in any sheet metal flashing or roof top equipment. Sheet metal screws shall not be used. Appropriate adhesive supports and construction mastic may be used on membrane roof surfaces only. Adhesive supports and construction mastic shall not be used on any sheet metal surfaces.

2.7 DOWN CONDUCTORS

- A. The structural steel columns of the building may be used as the main down conductor from the roof to ground for the lightning protection system providing it is electrically continuous and is in compliance with UL 96A and NFPA 780. The steel columns used shall in no case average over 60' apart. Where the steel columns are used, a connection to the top of steel shall be made thru the roof using a 1" fiberglass sleeve.
- B. All pitch pans or proper roof membrane flashings shall be furnished, installed, and weatherproofed by the roofing contractor.
- C. All 1" fiberglass sleeves shall be furnished, installed, weatherproofed, and maintained free from obstructions by the Electrical Contractor. All vertical system conductors shall be concealed.

2.8 GROUND RODS

- A. Ground rods and grounding perimeter grid shall be provided as part of the foundation electric package by this Contractor. Extend ground cable to the steel column and connect as indicated on the Contract Documents. Where the ground cable must be extended, all connections shall be made with exothermic welds.
- B. Ground rods shall be copper clad $\frac{3}{4}$ " x 10' minimum. One (1) set of tripod ground rods shall be installed for each down conductor.
- C. Ground plates of high conductivity copper sheet, 20 gauge minimum, 24" square may be used in lieu of or in combination with ground rods to achieve the five (5) ohm resistance grounding system requirement. Conductor attachments to the ground plates shall be via cast bronze bond plate of eight (8) square inches of contact area.
- D. Ground rods and/or ground plates shall be installed a minimum of one (1) foot below grade and a minimum of two (2) feet away from the building foundation. All grounding locations shall be evenly spaced around the building perimeter as possible.
- E. A minimum of one (1) ground inspection well, rated for traffic of the installation area, shall be installed for each down conductor.
- F. Bonding of the grounding systems shall be with main size conductors. The bonding shall be accomplished to achieve equal potential of all grounds.

PART 3 - EXECUTION

3.1 GROUNDING SYSTEM

- A. Common interconnection of all grounded systems within the building shall be accomplished using main size conductors and fittings. Grounded metal bodies located within the calculated bonding distance as determined by the formulas of the standards shall be bonded to the system using properly sized bonding conductors.

3.2 GROUNDING OF METAL ELEMENTS

- A. Interconnect and ground the mechanical piping system and equipment, antennas, satellite dishes, metal drain covers, ventilators, vent stacks, pipes, roofing or siding, ridge rolls, valleys, crickets, eaves troughs, downspouts, ladders, ducts, cold water supply piping, and any other metallic objects or surfaces of a size presenting a capacitance hazard, or within six (6) feet of any portion of the lightning protection system, including grade mounted items.

3.3 SERVICE AND TESTING

- A. The installation of equipment shall be done under the direct supervision of the equipment manufacturer and per the manufacturer's requirements.
- B. The lightning protection installing contractor shall provide photos and/or video of the installation, including but not limited to, air terminal mounting, bonding connections (waterline and structural steel) down conductors, ground rods/plates/grids and all buried, concealed or inaccessible connections and components. This information shall be forwarded to the manufacturer for evaluation, certification, archiving and documentation. A copy shall be submitted to the Owner.
- C. The ground resistance of the completed system shall be measured using IEEE "Fall of Potential Method" in the presence of the Architect/Engineer and shall be forwarded to the manufacturer. Ground resistance shall be five (5) ohms or less. Submit all testing data to the Engineer.
- D. Include all results in the O&M manuals.

3.4 COORDINATION

- A. The Contractor shall coordinate with other trades to insure a correct, neat and unobtrusive installation.
- B. The Contractor shall be responsible for bonding to the water services and/or electrical grounding system.
- C. The Contractor shall install approved "through-roof" connectors as specified. The roofing contractor shall be responsible for flashing, booting, or pitch panning all "through-roof" assemblies per roofing manufacturer's specifications.
- D. Approved through-roof assemblies only with solid bronze or stainless steel rods shall be allowed to penetrate the roof. In no instance shall the conductor be allowed to penetrate the roof. The roofing contractor shall be responsible for flashing, booting, or pitch panning all "through-roof" assemblies per roofing manufacturer's specifications.
- E. Conductor cable bonded to the building's steel structure shall be attached utilizing approved bonding plates measuring a minimum of eight (8) square inches in size. Conductor cable embedded in concrete columns shall be bonded to column rebar at both top and bottom locations.
- F. A ground loop counterpoise shall be installed per NFPA-780 specifications. The counterpoise loop shall be interconnected to the structure to assure equipotential grounding.

3.5 CORROSION PROTECTION

- A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

- B. Use conductors with protective coatings where conditions would cause deterioration of corrosion of conductors.

3.6 INSTALLATION

A. Lightning Protection System

1. The installation of the lightning protection system components shall be done in a neat and workmanlike manner.
2. Roof penetrations required for down conductors or for connections to structural steel framework shall be made using through-roof assemblies with solid bars and appropriate roof flashings. The roofing contractor shall furnish the methods and materials required at roofing penetrations of the lightning protection components and any additional roofing materials or preparations required by the roofing manufacturer for lightning conductor runs to assure compatibility with the warranty for the roof.
(Note: The roofing contractor shall be responsible for sealing and flashing all lightning protection roof penetrations as per the roof manufacturer's recommendations. The lightning protection roof penetrations and/or method of conductor attachment shall be addressed in the roofing section of the specifications.)
3. If the protected structure is an addition to or is attached to an existing structure that does not have a lightning protection system, the contractor shall certify that the system installed complies with the requirements of the Standards, and advise the owner of the lightning protection work required on the existing structure to obtain full certification for the structure. If the existing structure does have a lightning protection system, the contractor shall advise the owner of any additional work required on the existing system to bring it into compliance with current Standards and thus qualify for LPI or U/L certification.

3.7 FINAL SYSTEM INSPECTION AND QUALITY CONTROL

- A. The contractor shall furnish a UL Certificate upon completion of the installation.
- B. UL certification requires inspection by their third-party field staff after completion of the installation.
- C. As-Built Drawings shall be completed and stamped by an LPI Certified Master Designer - Installer of Lightning Protection Systems.
- D. Final Inspection Report – A final test and inspection report shall be completed based on ANSI/TIA/EIA 607, NEC, NFPA 780, and UL96A industry standards as applicable. The scope of the inspection and report shall include.
 1. Test and evaluation of the grounding system.
 2. Record final systems to ground resistance level.
 3. Evaluation and Testing of the internal bonding and grounding systems.
 4. Evaluation and Testing of equipment grounding.
 5. Evaluation of AC surge suppression installation.
 6. Evaluation of telco surge suppression installation.
 7. Copy of the UL Lightning Protection Certification.
 8. Final As-Built Review and submission.
- E. Report shall include detailed reporting and test results with corresponding photos of each evaluation category.

END OF SECTION

SECTION 264313

SURGE PROTECTION DEVICE

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide surge protection devices (SPD) for the protection of all AC electrical circuits and electronic equipment from the effects of lightning induced voltages, external switching transients and internally generated switching transients, in accordance with the Contract Documents.

1.2 WORK INCLUDED

- A. Surge Protective Devices

1.3 SUBMITTALS

- A. The surge protective device submittals shall include, but shall not be limited to, the following information:
 - 1. Data for each suppressor type indicating ratings, capacities, operating weight, conductor sizes, conductor types, and connection configuration and lead lengths.
 - 2. Manufacturer's certified test data indicating the ability of the product to meet or exceed requirements of this specification.
 - 3. Drawings, with dimensions, indicating SPD mounting arrangement and lead length configuration, and mounting arrangement of any optional remote diagnostic equipment and assemblies.
 - 4. List and detail all protection systems such as fuses, disconnecting means and protective materials.
 - 5. SPD wiring, bonding, and grounding connections shall be indicated on the wiring diagrams for each system. Include installation details demonstrating mechanical and electrical connections to equipment to be protected.

1.4 QUALITY ASSURANCE

- A. The latest edition of the following standards and publications shall comply to the work of this section:
 - 1. ANSI/IEEE C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits
 - 2. ANSI/IEEE C62.45, Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits
 - 3. Underwriters Laboratories UL 1449
 - 4. Underwriters Laboratories, UL 1283
 - 5. National Fire Protection Association, NFPA 70 and 780 - National Electrical Code
 - 6. National Electrical Manufacturer's Association LS-1, (NEMA LS-1)
 - 7. ISO 9001: Quality Systems - Model for Quality Assurance in Design, Development, Production, Installation and Servicing
 - 8. UL 96A – UL Lightning Protection System Master Label

- B. All surge protective devices for service entrance, distribution, and branch circuit protection within a facility shall be provided by a single manufacturer.
- C. The manufacturer must be regularly engaged in the manufacture of surge suppression products for the specified categories for no less than ten (10) years.

1.5 WARRANTY

- A. The SPD and supporting components shall be guaranteed by the manufacturer to be free of defects in material and workmanship for a period of ten (10) years from the date of substantial completion of service and activation of the system to which the suppressor is attached. Any additional diagnostic circuits (LEDs, surge counter, etc.) must meet the same warranty period and conditions listed within these specifications.
- B. An SPD that shows evidence of failure or incorrect operation during the warranty period shall be replaced free of charge. Since "Acts of Nature" or similar statements typically include the threat of lightning to which the SPDs shall be exposed, any such clause limiting warranty responsibility in the general conditions of this specification shall not apply to this section. That is, the warranty is to cover the effects of lightning, single phasing, and all other electrical anomalies. The warranty shall cover the entire device, not just various components, such as modules only.
- C. The installation of SPDs in or on electrical distribution equipment shall in no way compromise or violate equipment listing, labeling, or warranty of the distribution equipment.

PART 2 - PRODUCTS

2.1 PERFORMANCE

- A. General
 - 1. SPDs installed in switchgear, switchboards, or power panels shall have an integral non-fused disconnect, independently tested to the maximum surge current rating of the device. SPDs installed in lighting panels shall be either direct connected to the main bus or via a dedicated branch breaker. Use of plug-in type suppression modules is not allowed.
 - 2. SPDs installed external to switchgear, switchboards, or power panels shall be fed by a dedicated 30A/3P circuit breaker or disconnect switch. The SPD shall be connected directly to the side of the equipment enclosure.
 - 3. The SPD shall protect all modes and there shall be seven (7) discrete suppression circuits: three (3) modes connected Line to Ground, three (3) modes connected Line to Neutral, and one (1) mode connected Neutral to Ground for a 3-phase, 4-wire, plus ground voltage system. Line to Neutral to Ground is not an acceptable substitute for Line to Ground. Line to Neutral to Line and Line to Ground to Line (in combination) will be acceptable for Line to Line protection.
 - 4. All SPDs must have passed the UL 1449 Fault Current Test with a Rating of 200,000 AIC. Documentation substantiating this claim must be provided.
 - 5. SPDs shall use a separate path to building ground; the equipment safety ground is not to be used as a transient ground path. Ground to ground bar in the main service room. Provide cabling and conduit per manufacturer's requirement.
 - 6. Each metal-oxide varistors (MOV) shall be individually fused with a dual-purpose fuse at the component level (one (1) fuse system for each MOV). The fusing system must be comprised of a portion that will open in the event of a high fault current condition and a portion that will open in the event a limited fault current condition. This feature must be a standard design feature and not an optional feature of the product. The individual component level fusing shall allow a reduction of protection rather than a complete loss of

protection. Individually fused modules are not acceptable where there is more than one (1) MOV per module.

7. The maximum continuous operating voltage (MCOV) of all components shall not be less than 115% for 480Y/277V systems and 125% for 208Y/120V systems.
8. Standard diagnostic features are to include green LEDs (one (1) per phase - normally "ON") indicating power and suppression status, one (1) red LED indicating protection status (normally "OFF") and a form C dry relay contact.
9. Extended diagnostics must include an audible alarm and surge counter to be displayed on an LCD display on the front of the suppressor. The surge counter must include a reset option. Products requiring diagnostic test kits will not be acceptable.

2.2 SERVICE ENTRANCE PROTECTION

- A. The SPD for this location shall be as indicated on the Contract Documents.
- B. The service entrance SPD equipment shall meet or exceed the minimum performance criteria as follows:
 1. The single-impulse surge-current rating shall be a minimum of 300,000 Amperes per phase (150,000 Amperes per mode).
 2. Nominal discharge current rating (In): 20kA.
 3. Any SPD mounted on the line side of the service disconnect(s) shall be TYPE 1 rated. SPDs mounted on the secondary side of the service disconnect shall be TYPE 2 or TYPE 1.
 4. Minimum Surge Life Rating: 20,000 pulses.
 5. The UL 1449 Suppressed Voltage Protection Rating (VPR) for the following configurations shall not exceed the following:

SPD Voltage Configuration	L-G	L-N	N-G	L-L
480Y/277V	1800V	1800V	1800V	2500V
208Y/120V	1200V	1200V	1500V	1500V
480V Delta	2000V	—V	—V	3500V

- C. SPDs shall be of compact design. The mounting position of the SPD shall allow a straight and short lead-length connection between the SPD and the point of connection in the equipment.
- D. Visual indication of proper SPD connection and operation shall be easily viewed on the front panel of the enclosure. The indicator lights shall indicate suppression circuit status, phase status, phase loss, reduced protection level and suppression fault.
- E. Whereas there is no dedicated breaker in the protected electrical distribution equipment, the SPD shall be equipped with an integral disconnect switch.
- F. A set of normally open/normally closed form "C" dry contacts shall be provided for remote monitoring.
- G. The enclosure type shall be NEMA 1 rated for indoor installations and NEMA 4 rated for all outdoor.
- H. SPDs shall have a diagnostics LCD panel display providing information surge/transient event count.
- I. SPDs shall be equipped with an audible alarm with mute, reset and acknowledge features.

- J. The maximum value for the attenuation for the suppressor must exceed a minimum of 36 dB. All measurements for this requirement must be taken using the MIL STD 220A method and with only six (6) inches of lead length extending outside of the normal exit location of leads for the enclosure. Test results taken with leads extending past six (6) inches are not acceptable or compliant. Additional or excessive lead length used in the test setup is not acceptable.

2.3 SECONDARY DISTRIBUTION

A. Secondary Distribution Locations

- 1. Maximum Single Impulse Surge Current Rating: 80kA per mode.
- 2. Normal Discharge Current Rating (In): 20kA.
- 3. Minimum Surge Life Rating: 5,000 impulses.

B. Lighting Panels

- 1. Maximum Single Impulse Surge Current Rating: 60kA per mode (120kA per phase).
- 2. Nominal Discharge Current Rating (In): 20kA.
- 3. Minimum Surge Life Rating: 5,000.

C. Protection modes and UL 1449 VPR for grounded wye circuits with voltages of 480Y/277, 3-phase, 4-wire circuits shall be as follows:

- 1. Line to Neutral: 1200V.
- 2. Line to Ground: 1200V.
- 3. Neutral to Ground: 1200V.
- 4. Line to Line: 2000V.

D. Protection modes and UL 1449 VPR for grounded wye circuits with voltages of 208Y/120, 3-phase, 4-wire circuits shall be as follows:

- 1. Line to Neutral: 700V.
- 2. Line to Ground: 700V.
- 3. Neutral to Ground: 700V.
- 4. Line to Line: 1200V.

E. Protection modes and UL 1449 VPR for 240/120V, single-phase, 3-wire circuits shall be as follows:

- 1. Line to Neutral: 700V.
- 2. Line to Ground: 700V.
- 3. Neutral to Ground: 700V.
- 4. Line to Line: 1200V.

2.4 ACCEPTABLE MANUFACTURERS

- A. Eaton
- B. Asco Power
- C. Siemens
- D. Square D

- E. Surge Suppression Inc.

PART 3 - INSTALLATION

3.1 INSTALLATION

- A. Install correct fusing, circuit breaker, or disconnect to comply with the product UL 1449 listing.
- B. At Service Entrance or Transfer Switch, a UL listed disconnect switch shall be provided as a means of servicing disconnect if not connected to at least a 30A or 40A breaker.
- C. At distribution or branch, SPD shall have an independent means of servicing disconnect such that the protected panel remains energized. A 30A breaker (or larger) may serve this function.
- D. SPDs shall be installed per manufacturer's installation instructions with lead runs as short and straight as possible avoiding sharp corners. Gently twist conductors together to reduce impedance along the length.
- E. Installer may rearrange breaker locations to ensure short & straightest possible leads to SPDs. The location of field-mounted SPD devices must allow adequate clearances for maintenance.
- F. Use crimped connectors only; use of wire nuts is unacceptable.

3.2 FIELD QUALITY CONTROL

- A. Perform the following inspections below and submit written confirmation of results:
 - 1. Compare equipment nameplate data for compliance with the Contract Documents and Specifications.
 - 2. With grounded systems verify that electrical system bonding jumper has been connected between neutral and ground before any SPDs are energized.
 - 3. Verify compliance with Startup Service per below.
 - 4. Verify that proper operation indication lights are displayed on the SPD.
- B. An SPD device and installation will be considered defective if it does not pass the above tests and inspections.

3.3 STARTUP SERVICE

- A. Complete any startup checks according to the manufacturer's written instructions.
- B. Do not perform insulation resistance tests of the distribution wiring equipment with the SPD connected. Disconnect before conducting insulation resistance tests and reconnect immediately after the testing is over.
- C. Before energizing, installer shall verify service or separately derived system Neutral to Ground bonding jumpers per the NEC.
- D. Energize only after initial system voltages have stabilized and testing is completed. Warning, voltages are typically unstable during initial start-up of generators and voltage stabilizing transformers and can damage SPDs.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train the Owner's maintenance personnel to operate and maintain SPDs.

3.5 CLEANING AND ADJUSTMENT

- A. After completion, clean the interior and exterior of dirt, paint, and construction debris.
- B. Touch up paint all scratched or marred surfaces with factory furnished touch-up paint of the same color as the factory applied paint.
- C. Adjust and align equipment interior and trim in accordance with manufacturers' recommendations, and to eliminate gaps between the two.

END OF SECTION

SECTION 265000

LUMINAIRES AND ACCESSORIES

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Provide luminaires and accessories in accordance with the Contract Documents.
- B. Lamps shall be of the same manufacturer.
- C. Drivers and power supplies shall be of the same manufacturer for each fixture type.
- D. Equipment shall be certified for use in the State of the project and shall meet the State Energy Code and local energy ordinances.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.3 WORK INCLUDED

- A. Luminaires and accessories
- B. Exit signs.
- C. Emergency lighting units

1.4 SUBMITTALS

- A. Manufacturer's product data sheets for each luminaire indicating luminaire type, dimensions, driver quantity and type, module quantity and type, photometric data, materials, finishes, accessories, voltage, input watts, CFM data, and photographic image of luminaire.
- B. Scaled and dimensioned detail plan and elevation drawings of custom and continuous row type luminaires including joints, mounting points and type, power connection location(s), and emergency or separate switching configurations.
- C. Seismic restraint calculations.
- D. Manufacturer's product data sheets for each LED module specified. Include the following:
 - 1. Module wattage
 - 2. Modules voltage where applicable
 - 3. Rated lamp life.
 - 4. Mean lumen output.
 - 5. Correlated Color Temperature
 - 6. Color Rendering Index (CRI)
- E. Manufacturer's data for LED lighting systems for each luminaire type. Including:

1. Luminaire dimensions
2. Mounting
3. Power supply type and maximum remote mounting distance
4. System wiring diagram, differentiating between manufacturer-installed and field-installed wiring.
5. Control diagrams

1.5 QUALITY ASSURANCE

- A. Except as modified by governing codes and by the Contract Documents comply with the latest applicable provisions and latest recommendations of the following:
1. Ballasts: ANSI C82.2 and C82.11, FCC CFR 47 Part 18, Public Law 100-357, and UL 935 and 1029.
 2. Cords: UL 62.
 3. Exit Signs and Emergency Luminaires: NFPA 70 and UL 101 and 924.
 4. Lamp Holders and Starters: UL 496, 542, and 879.
 5. Luminaires: UL 57, 676, 1570, 1571, and 1572.
 6. Photometric data: Independent testing laboratory certified.

1.6 INSTALLER QUALIFICATIONS

- A. Any company specializing in performing work of the type specified in this section must:
1. Have a minimum of three (3) years of documented experience.
 2. Be approved by system manufacturer.
 3. Submit contact names and phone numbers for at least three references connected with successful past projects, with projects of similar difficulty and size.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Lighting Luminaires: Refer to Light Fixture Schedule shown in Electrical drawings and luminaire cutsheets.

2.2 SOLID STATE LIGHTING FIXTURES

- A. Housing, where applicable:
1. Steel bonderized or equal rust protected, or aluminum, rigid construction. Minimum gauge thickness shall be as follows:
 - a. Interior locations: No. 20 gauge steel, No. 16 gauge aluminum.
- B. Finish:
1. Baked enamel finish (except when otherwise specified).
 2. Concealed interior surfaces (this applies to interior hardware, circuit boards, etc.) matte black.
 3. Concealed exterior surfaces: matte black.
 4. Visible surfaces: color and texture as specified below for each fixture type or as selected.
 5. Exterior fixture finish: refer to "Exterior Fixture Finishes".

C. Light Emitting Diode (LED) requirements:

1. Correlated color temperature (CCT) for phosphor-coated white LEDs must have one (1) of the following designated CCT's and fall within the following binning standards:
 - a. 2700K defined as 2725 +/- 145K
 - b. 3000K defined as 3045 +/- 175K
 - c. 3500K defined as 3465 +/- 245K
 - d. 4000K defined as 3985 +/- 275K
2. Color spatial uniformity shall be limited to variations in chromaticity for different directions (i.e. changes in viewing angle) within 0.004 from the weighted average point on the CIE 1976 (u',v') diagram.
3. Color maintenance shall be limited to a maximum change in chromaticity of 0.007 on the CIE 1976 (u',v') diagram over the lifetime of the product.
4. Color rendering index (CRI)
 - a. Color rendering index to be determined using ANSI C78.377-2008 and applicable IESNA standards.
 - b. Laboratory tests must be produced using specific module(s)/array(s) and power supply combination that will be used in production.
 - c. Manufacturers must provide a test report from a laboratory accredited by NVLAP or one (1) of its MRA signatories.
5. Lumen Depreciation
 - a. Lumen depreciation to be measured using IESNA LM-80-08 standard for IES approved method of measuring lumen maintenance of LED light sources.
 - b. Phosphor coated white LED module(s)/array(s) shall deliver at least 70% of initial lumens for a minimum of 35,000 hours when installed in-situ and operated at 100% output and the maximum specified operating temperature.
 - c. Colored LED module(s)/array(s) shall deliver at least 50% of initial lumens for a minimum of 35,000 hours when installed in-situ and operated at 100% output and the maximum specified operating temperature.

D. Luminaire Efficacy:

1. Luminaire efficiency shall be measured using IESNA LM-79-08 standard for electrical and photometric measurements of solid state lighting products.
2. Manufacturer shall provide published luminaire efficacy, which is defined as luminaire light output divided by luminaire input power measured in a 25 degree Celsius environment. Efficacy shall include power supply, thermal, optical, and fixture losses.

E. Thermal Management:

1. Solid state light fixture shall not exceed LED manufacturer's maximum junction temperature requirements when operated in-situ at fixture manufacturer's maximum ambient operating temperature and 100% light output.
2. Solid state light fixtures shall be thermally protected using one (1) of more of the following thermal management techniques:
 - a. Metal core board
 - b. Gap pad
 - c. Internal monitoring firmware

3. Solid state lighting fixture housing shall be designed to transfer heat from the LED board to the outside environment.

F. Power Supplies/Drivers:

1. Power supply shall have a power factor of 0.90 or greater for primary application.
2. Power supply input current shall have Total Harmonic Distortion (THD) of less than 20%.
3. Power supply shall have a minimum operating temperature of minus 20 degrees Celsius or below when used in luminaires intended for outdoor applications.
4. Power supply output operating frequency to be equal to or greater than 120 Hz.
5. Power supply shall operate with sustained input variations of +/- 10% (voltage and frequency) with no damage to the driver.
6. Power supply shall tolerate sustained open circuit and short circuit output conditions without damage and without need for external fuses or trip devices.
7. Power supply output shall be regulated to +/- 5% across published load range.
8. Power supply shall have a Class A sound rating.
9. Power supply outputs shall have current limiting protection.
10. Power supply shall operate LEDs at constant and regulated current levels. LEDs shall not be overdriven beyond the diode manufacturer's specified nominal voltage and current.

G. Solid State Lighting Controls:

1. Control interface to dimmable power supplies shall consist of one (1) of the following:
 - a. Line Voltage Dimming. Controls to be rated for magnetic or electronic low voltage transformer operation.
 - b. Low voltage (0-10V) control. Controls to be compatible with either current sink or current source operation.
 - c. DMX control
2. Dimmable LED power supplies shall use pulse width modulation (PWM) to regulate power to LEDs.
 - a. Dimmable power supplies shall have 12-bit or greater resolution to obtain flicker-free operation throughout the dimming range.

H. System Installation:

1. All hardwired connections to solid state lighting fixtures shall be reverse polarity protected and provide high voltage protection in the event connections are reversed or shorted during the installation process.
2. All solid-state lighting fixtures (100% of each lot) shall undergo a minimum eight-hour burn-in test during manufacturing.
3. In addition to requirements identified in Section 1.04 SUBMITTALS, solid state lighting installations shall be UL Listed as a low-voltage lighting system including, but not limited to, luminaire, power supply, controller, keypad, and wiring.

I. Warranty:

1. All luminaires, drivers, and controllers for solid state lighting systems shall be covered by a five-year warranty against defects in workmanship or material. Warranty shall include in-warranty service program providing for payment of authorized labor charges incurred in replacement of inoperative in-warranty equipment.

2.3 MATERIALS AND FABRICATION

- A. Luminaires shall be completely factory assembled and wired, and equipped with necessary modules, drivers, power supplies, wiring, shielding, reflectors, channels, lenses, and other parts necessary to complete the luminaire installation.
- B. Luminaire hardware shall be concealed. Weld exposed metal at joints, fill with weld material, grind smooth, and make free from light leaks. Weld ballast support studs, socket saddle studs, and reflector support studs to luminaire body; self-threading screws are not acceptable. Luminaires shall be designed for bottom relamping, unless otherwise noted.
- C. Construct luminaires with a minimum number of joints. Unexposed joints by shall be welded, screwed, or bolted; soldered joints are not acceptable. Do not use self-tapping methods or rivets for fastening removable parts used to gain access to electrical components requiring service or replacement, or for fastening electrical components or their supports.
- D. Cast or extruded parts of luminaires shall be close grained and free from imperfections or discolorations, rigid, true to pattern, of ample weight and thickness, and properly fitted, filed, ground, and buffed to provide finished surfaces and joints free of imperfections.
- E. Housings for luminaires shall be designed to make electrical components easily accessible and replaceable, without removing the luminaire body from its mounting.

2.4 FINISHES

- A. Luminaire finishes shall provide a durable, wear resistant surface. Surfaces shall be chemically cleaned and treated with corrosion inhibiting (phosphating) material to assure positive paint adhesion. Exposed metal surfaces (brass, bronze, aluminum, etc.) and finished castings (except chromium plated or stainless steel parts) shall have an even coat of high grade methacrylate lacquer or transparent epoxy. Anodize exposed aluminum surfaces in a 20-minute bath for corrosion resistance. Sheet steel luminaire housings, and iron and steel parts which have not received phosphating treatment, or which are to be utilized in exterior applications, shall be zinc or cadmium plated, or hot dip zinc galvanized after completion of all forming, welding, and drilling operations.
- B. Screws, bolts, nuts, and other fastening or latching hardware shall be cadmium plated.
- C. Provide luminaires with a high temperature baked enamel coating of selected color and finish, unless otherwise noted. White baked enamel finished surfaces shall have a minimum reflectance of 86%, unless otherwise noted.
- D. Where the term "Custom Color" is used in the Luminaire Schedule and elsewhere in the contract documents, it indicates that the luminaire shall be factory painted to match a color chip provided by the Architect. Unless noted otherwise, each luminaire type identified as a custom color shall be considered to be a different color from other "Custom Color" luminaire types.

2.5 REFLECTORS

- A. Aluminum Reflectors:
 - 1. Reflectors and reflecting cones or baffles shall be fabricated from #12 aluminum reflector sheet, minimum 0.057 inches thick (15 gauge). Material shall be free of tooling marks, spinning lines, and marks or indentation caused by riveting or other assembly techniques. No rivets, springs, or other hardware shall be visible after installation.
 - 2. Reflectors and baffles shall be polished, buffed, and anodized (Alzak), with finish color as

selected by the Architect.

B. Painted Reflectors:

1. Painted reflectors shall be formed before application of primer and paint. Reflectors and reflector bodies for luminaires with baked white enamel finish shall meet the following requirements and tests:
 - a. After 100 hours of exposure to fade-o-meter, reflectance shall be not less than 86%, and finish shall show no visible color change.
 - b. After 100 hours of exposure to 100% humidity at 100°F, (cook box test) finish shall show no blistering or other degraded effects.
 - c. After 150 hours of exposure to salt spray (20% sodium chloride) shall cause no breakdown of film.

2.6 LENSES, FACEPLATES AND TRIMS

- A. Plastic lenses shall be of virgin methyl methacrylate, unless otherwise indicated. Polystyrene lenses are not acceptable.
- B. Lenses, louvers, and other light diffusing components shall be contained in frames. Lenses shall be removable but positively held within the frames so that hinging or other motion of the frame will not cause the diffusing components to drop out.
- C. Faceplates on recessed luminaires shall open for access to the interior of the luminaire, serve as a ceiling trim, and positively held to the luminaire body by adjustable means that permit the faceplate to be drawn up to the ceiling as tight as necessary to insure complete contact of faceplate with the finished ceiling.
- D. Provide ceiling trims for rectangular recessed luminaires with mitered corners, continuously welded and smoothed before shop finishing. Lapping of trim metal is not acceptable.

2.7 LUMINAIRE WIRING

- A. Provide wiring between LED modules and drivers of same or heavier gauge than the leads furnished with the drivers and having same or higher insulating and heat resisting characteristics. Internal wiring of luminaires shall contain a minimum number of splices. Splices shall be made with suitable mechanical insulated steel spring type connectors.
- B. Wiring channels and wireways shall be free from projections and rough or sharp edges. Provide bushings at points or edges over which conductors pass.

2.8 EXTERIOR FIXTURES

- A. Provide fixtures designed and manufactured specifically for outdoor service. Make components, including nuts, bolts, rivets, springs, and similar parts, of corrosion resistant materials or of materials which will assure such resistance.
- B. Provide fixtures for use outdoors, or in areas designated as damp locations, which are suitably and effectively gasketed to prevent access of moisture into electrical components or enclosing diffusers, lenses, or globes. Outdoor fixtures which are directly exposed to the elements shall be rated for wet locations. Fixtures which are aimed up, shall be approved for wet locations in this position.

- C. Metal parts of fixtures requiring painting, shall be painted with suitable weather and moisture-resisting paint equal to epoxy-based coatings.
- D. Provide anodized aluminum for aluminum parts of exterior fixtures which are not specified as requiring a painted finish.
- E. Installations shall be UL labeled as "Suitable for Wet Locations."
- F. Surfaces shall be prepared, primed and material applied in accordance with manufacturer's requirements.
- G. Supply pole luminaires with davit arms, brackets, pole hand-hole covers, base components, and all other accessories complete by specified manufacturer who will be responsible for proper fitting of all elements.
- H. Manufacturer will supply pole luminaire assembly to withstand a minimum of 100-mile-per hour winds with a 1.3 gust factor without permanent deflection.
- I. Manufacturer shall be responsible for the structural integrity of complete pole luminaire. Contractor shall provide below grade concrete base as needed for each bollard or pole mount type light fixture.

2.9 ACCESSORIES

- A. Where utilized as raceways, luminaires shall be suitable for use as raceways. Provide feed through splice boxes where necessary.
- B. Provide installation and supporting hardware including stems, plates, plaster frames, hangers, and similar items, for support of luminaires for the ceiling construction in which they shall be installed. Provide plaster frames made of non-ferrous metal, or of steel that has been suitably rustproofed after fabrication.
- C. Provide fastening devices of a positive locking type, which do not require special tools to apply or remove them. Do not use tie wires in place of fastening devices.
- D. Attach reflectors to housing by means of safety chains to prevent reflectors from falling. No part of the chain shall be visible after installation.
- E. Provide a ceiling canopy for each stem. Canopy finish shall match stem finish.
- F. Provide stems (size verified in field) to extend the exit signs to be lowered such that the fixture bottom is equal to surrounding fixtures.
- G. Luminaires installed in air plenums shall be enclosed and gasketed.
- H. Provide additional feed points in pendant mounted luminaires connected to the emergency power system or provided with integral battery packs to accommodate the additional wiring.

2.10 EMERGENCY LIGHTING

- A. General
 - 1. Provide emergency lighting as required by referenced standards and indicated on the Contract Documents. The main function of emergency lighting is to direct building

- occupants safely out of the building in the event of an emergency.
- 2. Connect emergency lighting to the emergency power distribution systems.
- 3. Provide integral battery ballast power for emergency lighting where an emergency power distribution system does not exist. Provide all long-life batteries. High temperature, maintenance free, nickel-cadmium batteries are acceptable, however, lead-calcium type are not.
- 4. All battery ballasts shall be capable of providing full illumination in emergency mode.

B. Exit Signs

- 1. Exit signs shall have cast-aluminum housings and stencil edge-lit faces. Letters shall be red and 8" high. Light source shall be light emitting diodes (LED). Exit signs shall employ a diffuser lens for even illumination of letters. Products that exhibit "dots" or "hot spots" shall not be acceptable. Exit signs shall have internal sealed lead calcium maintenance free battery rated for 90 minutes.

C. LED Battery Systems

- 1. Emergency battery power supply suitable for installation remote from or in the driver compartment of the LED luminaire. Unit shall be capable of providing normal fixture operation in a switched fixture. Include "TEST" switch and "AC ON" indicator light capable of installation in the luminaire or remote from the luminaire. Power supply shall have self-test diagnostic feature.
- 2. Emergency battery power supply shall be capable of operating the LED fixtures specified.
- 3. Provide LED battery with the following:
 - a. Rated input and output voltage and wattages.
 - b. Temperature rating.
 - c. Illumination time (minimum 90 minutes).
 - d. Suitable for indoor and damp locations and for sealed and gasketed features.
- 4. LED battery shall meet all associated UL ratings, including UL924.

PART 3 - EXECUTION

3.1 GENERAL

- A. Luminaire locations as indicated on the Contract Drawings are general and approximate. Verify exact location of luminaires with Architect prior to installation. Verify adequacy of clearance with other equipment such as ducts, pipes, conduit, or structural elements. Bring conflicts to Architect's attention before proceeding with work.
- B. Verify ceiling construction and furnish appropriate luminaire mounting supports, hardware, trim, and accessories for each luminaire.
- C. Install luminaires in mechanical equipment rooms after ductwork and piping installation. Locate and mount luminaires as indicated on the Contract Drawings unless mechanical equipment prohibits or makes it impractical to do so. In such cases, chain, or wall mount luminaires so that serviceable equipment is illuminated.
- D. Luminaires shall be installed free of light leaks, warps, dents, or other irregularities. Light leaks are not acceptable.

- E. Install reflector cones, aperture plates, lenses, diffusers, louvers, and decorative elements of luminaires after completion of wet work, plastering, painting, and general clean up in the area of the luminaires.
- F. Provide final focusing and adjusting of adjustable lighting equipment. Focusing and adjusting shall be performed under the Architect's supervision after normal working hours.
- G. Parabolic luminaires shall be installed with mylar cover over louvers. Cover shall be UL listed for temporary lighting. Upon completion of work, remove mylar cover with white gloves.
- H. Visible hanging devices shall be finished to match the luminaire finish, unless otherwise noted. Suspended fixtures shall hang level and aligned when installed in rows.
- I. Provide fire rated enclosures around recessed luminaires that are installed in fire rated ceilings.
- J. Provide attachment devices, brackets, plaster rings, saddle hanger and tie bars made of formed, rolled, or cast metal shapes with the requisite rigidity and strength to maintain continuous alignment and support of installed luminaires.
- K. Luminaires mounted in suspended ceilings shall be attached to the main runners of the ceiling system with appropriate mounting hardware. Provide independent 450 slack cables from corners of luminaires to structure above.
- L. Equipment requiring access for service and maintenance shall be installed so that components requiring access are readily accessible.
- M. Immediately prior to occupancy clean reflectors, reflector cones, aperture plates, lenses, trim rings, faceplates, louvers, lamps, and decorative elements.
- N. Replace defective modules and noisy or defective drivers.
- O. All fixtures shall be fully cleaned prior to occupancy.

3.2 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage then replace damaged fixtures and components. Verify normal operation of each fixture after installation.
- B. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify normal transfer to battery power or emergency power source and retransfer to normal.
- C. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. Retest to demonstrate compliance with specification requirements where adjustments are made. Replace fixtures with damage or corrosion during warranty period.

3.3 SPARE PARTS

- A. Provide spare materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Provide at least one (1) of each type.
 - 1. LED Modules: Five (5) for every 100 of each type and rating installed.
 - 2. Plastic Diffusers and Lenses: One (1) for every 100 of each type and rating installed.
 - 3. Battery and Charger: One (1) for every 20 emergency lighting units installed.

4. LED Drivers: One (1) for every 100 of each type and rating installed.
 5. Globes and Guards: One (1) for every 20 of each type and rating installed.
 6. Exit Signs: Ten (10) additional exit signs to be installed at locations determined in the field, if necessary. If not used in the field, turn over to the Owner for attic stock. Include in base bid 200 feet of wiring and conduit for each exit sign to be located in the field by the AHJ.
- B. Submit Operations and Maintenance instructions, including parts list, for each luminaire installed.

END OF SECTION

SECTION 270800

COMMUNICATIONS SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 RELATED SECTIONS

- B. Division 27 – Communications
- C. Section 019113 - General Commissioning Requirements

1.3 REQUIRMENTS

- A. The Commissioning process requires the participation of Division 27, Communications, to ensure that all systems fulfill the functional and pre-functional requirements set forth in these construction documents. The general commissioning requirements and coordination are detailed in Section 019113. Division 27, Communications, shall fulfill commissioning responsibilities assigned to Division 27 in accordance with Section 019113.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PRE-FUNCTIONAL CHECKLISTS

- A. Pre-functional checklists assist in the process to document that the equipment and systems are installed properly.
- B. The contractor will be provided with construction checklists from the CA for completion. The contractor shall complete the checklists as provide the CA with completed copies in accordance with 019113.
- C. See attached for a sample pre-functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.2 FUNCTIONAL PERFORMANCE TESTING

- A. Intent of functional performance testing is to prove thru functional test procedures proper system operation.
- B. The contractor will be provided with functional performance test procedures to perform while CA witnesses. The contractor shall perform functional tests in accordance with 019113.
- C. See attached for a sample functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.3 PREFUNCTIONAL CHECKLISTS AND FUNCTIONAL PERFORMANCE TESTING

- A. Pre-Functional Checklists and Functional performance testing procedures will be performed on the following system types. (Pre Functional and Functional performance testing requirements are in addition to and do not replace any testing required elsewhere in Division 27 or by applicable codes.) Equipment specifically marked as such below shall be provided with start-up of equipment by factory-authorized service representative.

- 1) Telecommunications
- 2) PA, Clock and Public Address Systems

3.4 SAMPLE CHECKLISTS

- A. See Attached.

END OF SECTION

SAMPLE ONLY

Functional Test

PA, Paging and Master Clock System

1. Participants

Discipline	Name	Company
CxA		
Mechanical		
Controls		
TAB		
Plumbing		
Electrical		
Date Returned to CxA		

2. Prerequisite Checklist

Check	Description
<input type="checkbox"/>	The above equipment and systems integral to them are complete and ready for functional testing.
<input type="checkbox"/>	All control system functions for this and all interlocking systems are programmed and operable per contract documents, including final setpoints and schedules with debugging, loop tuning and sensor calibrations completed.
<input type="checkbox"/>	Test and balance completed and approved for the hydronic systems and terminal units connected
<input type="checkbox"/>	All A/E punchlist items for this equipment corrected.
<input type="checkbox"/>	Safeties and operating ranges reviewed.
	Schedules and reviewed
	<ul style="list-style-type: none">This checklist does not take the place of the manufacturer's recommended checkout and startup procedures.Items that do not apply shall be noted with the reasons on this form (N/A = not applicable, BO = by others).Contractors assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off.

3. Installation and Operational Checks

Check		Comments
General Installation		
Surfaces, coatings, finishes and equipment is without damage	<input type="checkbox"/>	
All wiring fastened and tied in an approved workmanship manner	<input type="checkbox"/>	
All material and equipment new and unused	<input type="checkbox"/>	
Paging / Public Address System: (Telephone/Intercom)		
Page system interfaced to local sound systems	<input type="checkbox"/>	
Ceiling , wall and horn speakers provided with appropriate support structures	<input type="checkbox"/>	
Paging to individual zones, multiple zones and all call	<input type="checkbox"/>	
Program distribution to selected rooms, zones or all speakers	<input type="checkbox"/>	
Paging control unit accepts input from standard telephone.	<input type="checkbox"/>	
Emergency page override provided on remote program and micro-phone interface.	<input type="checkbox"/>	
Public address microphones mixer pre-amp/amplifiers provided	<input type="checkbox"/>	
Public address speakers in all assembly areas	<input type="checkbox"/>	
Assisted listening system provided	<input type="checkbox"/>	
Master Clock System:		
GPS based wireless Central Clock System provided	<input type="checkbox"/>	
Secondary clocks continuously synchronized with Master	<input type="checkbox"/>	
Master clock integrated into Telecenter ICS.	<input type="checkbox"/>	
Bell tones are operational (with 8 schedule capacity)	<input type="checkbox"/>	

4. Functional & Operational Testing Record

Test #	Mode ID	Test Procedure	Expected Response	Pass Y/N	Note
1	Paging System	Simulate a page via the central page as well as a page from room to room	The central page will be heard throughout the building. The page from room to room will only be heard in the room the page is directed to.		
2	Public Address System	Using the head end microphone, simulate a public address situation and ensure that all speakers are operational. It is best to play music if possible so you can walk the school to ensure all areas are operational.	Walk through the building and ensure that all areas will hear the public address through the speakers loudly and clearly.		
3	Master Clock System	Check all clocks to ensure that the time is accurate and that the secondary clocks are following the master clock setting	The master clock controls all clocks and the time is accurate.		
4	Bell Tone	During school hours when there is a change in class, observe the bell tone and ensure that it is following the schedule properly and is heard throughout the school	Walk through the building to ensure that the bell tone is heard throughout and that it is following the appropriate schedule.		

SECTION 27 10 00
COMMUNICATIONS
(Trade Sub-Sub-Bid Required as part of Section 26 00 00)

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SECTION 27 10 00
COMMUNICATIONS
(Trade Sub-Sub-Bid Required as part of Section 26 00 00)

PART 1 - GENERAL

1.1 TRADE SUB-BID REQUIREMENTS

- A. The Procurement and Contracting Requirements as listed in the Table of Contents, and applicable parts of Division 01 - General Requirements, shall be included in and made a part of this Section.

1.2 TRADE BID REQUIREMENTS

- A. Trade Contractor on this Project are required by law to provide Payment and Performance Bonds for the full value of his Trade Contract. Trade Contractor must include the full cost of the required Payment and Performance Bonds in the Bid price submitted to complete the Work of this Section. Trade Bids will only be accepted from Trade Contractors pre-qualified by the Awarding Authority.
- B. All Trade-Bids shall be submitted on the Trade Contractor Bid Form, included in the Specifications, in accordance with requirements of Chapter 149A of the Massachusetts General Laws, as amended.
- C. The attention of Trade Bidders is directed to Instructions to Bidders and Paragraph E of the Trade Contractor Bid Form. Trade-Bids shall be filed with the Awarding Authority in accordance with requirements stipulated therein.

1.3 RELATED DOCUMENTS

- A. All the Contract Documents, including Drawings, General Conditions, Supplementary Conditions, and all Sections of Division 01 - General Requirements, apply to the Work of this Section.
- B. The Trade Contractor for this Section shall examine all Drawings and all Sections of the Specification for requirements therein that may affect the Work of this Section, not just those Drawings and Specifications particular to the Work of this Section. The Work of this Section is shown primarily on the following listed Drawings:
 - 1. Architectural, "A" Drawings
 - 2. Electrical "E" series drawings
 - 3. Technology and Security drawings: T0-0-1 through T3-1
- C. The listing of the Contract Drawings above shall not limit responsibility to determine full extent of work of this Section as required by all Contract Drawings noted on the Contract Drawings-Title Sheet Drawing List, the Project Manual, and Addenda.

1.4 SUMMARY

- A. Provide and install data, voice, and audiovisual cabling infrastructure and equipment as specified herein.
 - 1. All Category 6e components of the structured premises Unshielded Twisted Pair cabling system specified herein including cabling, equipment, and connecting hardware shall be compliant with TIA/EIA-568-C Category 6 standards and exceed the performance requirements for Category 6.

2. All Category 5e components of the structured premises Unshielded Twisted Pair cabling system specified herein including cabling, equipment, and connecting hardware shall be TIA/EIA 568 Category 5e compliant.
 3. The system shall be installed to exceed Category 6 application performance requirements of TIA/EIA 568-C.
 4. Where the Drawings, Specifications, Codes, Regulations, Laws, or the requirements of the local Authority conflict, provide the higher quality and higher quantity indicated or required, and follow the most stringent requirement.
- B. The work under this Contract includes provision of all material, labor, equipment, and supplies, and the performance of all operations to provide complete working structured premise and audiovisual cabling systems, as required by the Drawings and details, and as specified herein. In general, the work includes, but is not limited to, the following:
- C. Extend all system backbone cabling from DEMARC to the MDF/MCER Room as required.
- D. Section Includes:
1. CMR Rated Cabling Systems.
 - a. Data and Voice Cabling Systems including
 - 1) Multimode and Single-mode Fiber Optic Backbone Cabling.
 - 2) Category 6e Horizontal Cabling.
 - 3) Multi-pair Category 5e Riser Backbone Cabling.
 - 4) Demarc to MDF Cabling.
 - 5) Connectors and Couplings.
 - 6) Innerduct.
 - 7) Cross-connections to dedicated phone lines.
 - 8) Equipment Racks and Cabinets.
 - 9) Patch Panels.
 - 10) Cable Management.
 - 11) Work Area Outlets/Network Interface Outlets.
 - 12) Faceplates
 - 13) Modular Jacks.
 - 14) Patch Cables and Line Cords.
 - 15) Innerduct.
 - 16) Connectors and Couplings.
 - 17) Access Point Equipment Enclosures.
 - 18) Labeling.
 - 19) Testing and Certification of Cabling.
 - 20) Test Reports.
 - 21) As-built Drawings.
 - 22) Training.
 - 23) Warranties.
 - b. Classroom Audio-Visual Cabling.
 - 1) HDMI Cabling.
 - 2) VGA Cabling.
 - 3) Audio Cabling.
 - 4) AV Patch Cables and Line Cords.
 - 5) Labeling.

- 6) Testing and Certification of Cabling.
- 7) Training.
- 8) Warranties

c. Local Control Cabling

- 1) Home Run Cat. 6E Cabling.
- 2) Line Cords.
- 3) Labeling.
- 4) Testing and Certification of Cabling.
- 5) Warranties.

- d. Terminations.
- e. Surge and Lightning Protection for Copper Cabling.
- f. Protection of New and Existing Work.
- g. Staging.
- h. Nameplates, Labels, and Tags.
- i. Access Panels and Doors.
- j. Coordination with Manufacturers, Other Trades, and Owner.
- k. Training on all systems.
- l. Operation and Maintenance Manuals for the work of this Section.

E. Provide and maintain in safe adequate condition all staging and scaffolding required for the proper execution of the work of this Contract.

F. Remove and re-install all ceiling tiles as required for the work of this Section.

1. Replace all ceiling tiles damaged as a result of the work of this Section at no cost to the Owner.

G. The Contractor shall perform daily clean-up of areas of work under this Section and remove all trash from the site.

H. Coordination of work with that of all other trades affecting or affected by work of this Section.

1. Cooperate with such trades to assure the steady progress of all work under this Section.

1.5 RELATED SECTIONS

A. Related Sections include the following:

1. Section 26 00 00 "Electrical"
2. Section 26 05 26 "Grounding and Bonding"
3. Section 26 05 33 "Raceways and Boxes"
4. Section 28 16 00 "Integrated Electronic Security System"

B. Except for coordination, or unless otherwise indicated, the following work is not included as part of the Contractor's responsibilities in this SECTION, and is to be performed by others as indicated:

1. Power Requirements shall be provided by the Electrical Contractor.
2. Costs associated with core drilling and cutting and patching, using appropriate and trained tradesmen approved by the Construction Manager and the Engineer, shall be provided by the Electrical Contractor.
3. Cutting and Patching shall be provided by Electrical Contractor.
4. Surface-mounted metal raceway shall be provided by the Electrical Contractor.

5. Cable tray, ladder rack, and snake tray shall be provided by the Electrical Contractor.
6. Sleeves for cable pathways shall be provided by the Electrical Contractor.
7. Empty conduits to accessible point above ceiling or below floor shall be provided by the Electrical Contractor.
8. Floor boxes and poke-through devices shall be provided by the Electrical Contractor.
9. Standard device boxes with plaster rings for the Cabling Systems shall be provided by the Electrical Contractor.
10. Structural blocking to support wall and ceiling-mounted televisions/monitors shall be provided by the Construction Manager.
11. Fireproofing of Penetrations and Openings shall be provided by Electrical Contractor.
12. Intrusion Alarm, Access Control and Video Surveillance CCTV active equipment and programming will be provided under Section 28 16 00.
13. Voice/Telephone equipment will be provided by the Owner under separate contract.
14. Data electronic equipment (computers, active data electronics, and peripherals) and final connections to patch panels and wall outlets will be provided by the Owner under separate contract.
15. Video Presentation equipment will be provided by the Owner under separate contract.
16. Interface with public utilities telephone service will be arranged by the Owner's service provider, and coordinated with this Section's Contractor.
17. I-Loop and Wide Area Network outside cabling plant will be provided by the Owner's service providers and coordinated with this Section's Contractor.
18. The installation, operating cost, and maintenance of the controlled environmental conditions for equipment located on site, as required by the manufacturer, NFPA 70B, or as specified in these specifications, shall be the responsibility of the Construction Manager.

1.6 DEFINITIONS

- A. Furnish: The term "furnish" is used to mean "supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, and similar operations."
- B. Install: The term "install" is used to describe operations at project site including the actual "unloading, unpacking, rigging in place, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations."
- C. Provide: The term "provide" means to "furnish and install, complete and ready for the intended use".
- D. SECTION: The terms "SECTION," "Section," and "Contract" refer to the requirements of the work to be performed as specified herein.
- E. Contractor: The terms "Contractor," "Installer," and "Cabling Contractor" refer to the entity awarded a contract for the work of this Section.
- F. Category 6e: The terms "Category 6e and Cat. 6e" refer to structured premises Unshielded Twisted Pair cabling components which are labeled by the manufacturer as "ENHANCED Category 6E, Category 6e, Category 6e+, or Category 6+" and are tested and certified by the manufacturer to exceed the performance requirements of TIA/EIA 568-C standards for Category 6.
- G. Cable Bundle: The term "Cable Bundle or Bundled Cables" are defined as two or more cables continuously bound together by cable ties, Velcro strips, strings, or helical wrap to form a single unit.
- H. Acronyms:
 1. AFF – Above Finished Floor

2. ANSI – American National Standards Institute
3. ICEA – Insulated Cable Engineers Association
4. AOR – Area of Refuge/Rescue
5. AV – Audio Visual
6. BAS – Building Automation Systems
7. BDF – Building Distribution Frame
8. BICSI – Building Industry Consulting Service International
9. CATV – Cable Television
10. CCTV – Closed Circuit Television
11. DEMARC – Demarcation Point
12. EF – Entrance Facility
13. EIA - Electronics Industries Association
14. ER – Equipment Room
15. HVAC – Heating, Ventilating, and Air-conditioning
16. IDC - Insulation-Displacement Connections
17. IDF/ICER – Intermediate Distribution Frame or Intermediate Communications Equipment Room
18. LAN – Local Area Network
19. MDF/MCER – Main Distribution Frame or Main Communications Equipment Room
20. NEC - National Electrical Code
21. NEMA - National Electrical Manufacturers Association
22. NFPA - National Fire Protection Association
23. MH – Maintenance Hole
24. OEM – Original Equipment Manufacturer
25. OSHA - Occupational Safety and Health Administration
26. OTDR – Optical Time Domain Reflectometer
27. PoE – Power over Ethernet, IEEE 802.3af standard
28. RCDD – Registered Communications Distribution Designer
29. RF – Radio Frequency
30. RMU – Rack Mount Unit
31. RPS – Redundant Power Supply
32. SCTE - Society of Cable Television Engineers
33. SMATV – Satellite Master Antennae Television
34. SP – Standards Proposal (TIA/EIA)
35. TIA – Telecommunications Industry Association
36. TLT – Telecommunications Infrastructure Layout Technician
37. TR – Telecommunications Room
38. TSB – Technical Systems Bulletin (TIA/EIA)
39. UL - Underwriters Laboratories
40. UPS – Uninterruptible Power Supply
41. UTP – Unshielded Twisted Pair
42. VoIP – Voice over IP Telephone System.
43. VMIU – Video Mask Interdiction Unit
44. WAO – Work Area Outlet
45. WAP – Wireless Access Point
46. WI-FI – Wireless Fidelity
47. WLAN – Wireless Local Area Network

1.7 REGULATORY REFERENCES

- A. Comply with applicable requirements of the following standards and those others referenced in their SECTION.
- B. All work and materials shall conform in every detail to the rules and requirements of the National Fire Protection Association, the local Electrical Code and present manufacturing standards.

- C. All materials shall be UL Listed and shall be marked as such. If UL has no published standards for a particular item, then other national independent testing standards shall apply and such items shall bear those labels. Where UL has an applicable system listing and label, the entire system shall be so labeled
- D. All materials shall be ETL Verified (not just tested) to be Category 6e component and channel compliant.
- E. Materials and equipment shall be manufactured, installed and certified as specified in the latest editions of applicable publications, standards, rulings and determinations: The Contractor shall comply and reference the latest editions of the following standards including any related addendum or TSB's not listed below:

1.8 PERFORMANCE REQUIREMENTS

- A. Include GENERAL CONDITIONS, SUPPLEMENTARY GENERAL CONDITIONS and applicable parts of Division 1 as part of this SECTION.
- B. Examine all Project Specifications and Drawings for requirements that affect work of this SECTION, whether or not such work is specifically mentioned in this SECTION.
- C. Materials and equipment shall be manufactured, installed, and certified as specified in the latest editions of applicable publications, standards, rulings, and determinations: The Contractor shall comply and reference the latest editions of the following standards including related addendum or TSB's not listed below:
 - 1. ANSI/TIA/EIA-526-7, Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
 - 2. ANSI/TIA/EIA-526-14-C, Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant
 - 3. ANSI/TIA/EIA-568-C.0, Generic Telecommunications Cabling for Customer Premises
 - 4. ANSI/TIA/EIA--568-C.1, Commercial Building Telecommunications Cabling Standard Part 1: General Requirements
 - 5. ANSI/TIA/EIA-568-C.2, Balanced Twisted-Pair Telecommunications Cabling and Components Standards
 - 6. ANSI/TIA/EIA-568-C.3, Optical Fiber Cabling Components Standard
 - 7. ANSI/TIA/EIA -569-D, Telecommunications Pathways and Spaces
 - 8. ANSI/TIA/EIA--598-D, Optical Fiber Cable Color Coding
 - 9. ANSI/TIA/EIA-606-B, Administration Standard for Commercial Telecommunications Infrastructure
 - 10. ANSI/TIA/EIA-607-B, Commercial Building Grounding and Bonding Requirements for Telecommunications
 - 11. ANSI/TIA/EIA 310D, Cabinets, Racks, Panels and Associated Equipment
 - 12. BICSI, TDMM, Telecommunications Distribution Methods Manual (TDMM)
 - 13. BICSI, Information Technology Systems Installation Methods Manual (ITSIMM)
 - 14. BICSI, Outside Plant Design Reference Manual (OSPDRM)
 - 15. BICSI, Electronic Safety and Security Design Reference Manual (ESSDRM)
 - 16. ANSI
 - 17. FCC Part 15 (addresses electromagnetic radiation).
 - 18. FCC Part 68 (connection of premises equipment and wiring to the network).NEC – National Electric Code (NEC)
 - 19. National Electrical Safety Code Handbook. (NESC)
 - 20. NFPA-70 – National Fire Protection Association (NFPA – 70)
 - 21. State and Local Building Codes.

1.9 SUBMITTALS

- A. Submit under the provisions of Division 01 Section "Submittal Procedures".
- B. LEED Submittal – refer to Division 01 Sustainable Design Requirements.
1. LEED submittals are in addition to other submittals. If submitted item is identical to that submitted to comply with other requirements, submit duplicate copies as a separate submittal to verify compliance with indicated LEED requirements.
 2. Project Materials Cost Data: Provide statement indicating total cost for materials used for Project.
 3. LEED Action Plans: Provide preliminary submittals indicating how the following requirements will be met:
 - a. Construction Waste Management: in compliance with Division 01 Section "Construction Waste Management."
 - b. List of proposed materials with recycled content: Manufacturers certification of recycled content indicating percentage by weight of both pre-consumer and post-consumer recycled content.
 - c. Local/Regional Materials:
 - 1) Sourcing location(s): Indicate location of extraction, harvesting, and recovery of raw materials used in the products manufacturing; indicate distance between extraction, harvesting, and recovery and the project site.
 - 2) Manufacturing location(s): Indicate location of manufacturing facility; include distance between manufacturing facility and the project site.
- C. Submit within (30) days of Contract award and prior to installation of any materials or equipment complete shop drawings, product data, schedule of values, and qualification documentation to the Architect for approval review.
1. SUBMIT ALL ITEMS IN A SPECIFICATION SECTION AT THE SAME TIME An incomplete submittal will be held until a complete submittal is accumulated, or may be rejected without further review and returned to the applicable parties. .
- D. Provide a Bill of Materials that clearly identifies the information requested herein for each and every item submitted. Include the Specification Paragraphs pertaining to each item submitted The Bill of Materials shall include the following "headings" in the order indicated from left-to-right on the Bill of Materials Index/Equipment List:
1. Item Number
 2. Manufacturer's "Name" for each item
 3. Manufacturer's "Model Number" for each item
 4. Manufacturer's "Description" of each item
 5. "Specification Section Number", reference specification section number/location for the item submitted.
 - a. Example of Specification Section number/location: 2.13, B., 7., c., 4), e), page number
6. Bill of Material Header Example:

Item #.	Mfr. Name	Mfr. No.	Description	Spec Ref	Qty	Pg. No.
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7. All Bill of Material items shall be listed in the Bill of Material Index / Equipment List, in the same order as they appear in the specification.
 8. On each and every data sheet, indicate the applicable part numbers(s) on the sheet(s) by one of the following methods:
 - a. Circling the applicable part number(s)
 - b. Putting an arrow next to the applicable part number(s)
 - c. Highlighting the applicable part number(s)
 9. Shop drawings shall include but not be limited to the following:
 - a. Built-in station arrangement.
 - b. Equipment cabinet arrangement.
 - c. One-line drawings.
 10. Include in the submittal:
 - a. Warranty information for all components, including a letter from manufacturers verifying the proposed cabling and materials are eligible for a 25-year manufacturer's warranty.
 - b. Qualification Data: For qualified Contractor.
 - c. Field quality-control reports.
 - d. Operation and Maintenance Data.
 - E. If proposed equipment deviates from the Specifications or Drawings, indicate in writing on Company letterhead those differences and provide sufficient data to justify acceptance. FAILURE TO INDICATE DEVIATIONS OR SUBSTITUTIONS IMPLIES FULL COMPLIANCE WITH DRAWINGS AND SPECIFICATIONS.
 - F. It is intended that Submittal be complete and accurate at the first submission.
 1. Submit all required Submittal information at one time.
 2. An incomplete Submittal shall be rejected in its entirety.
 - G. A minimum period of (15) working days, exclusive of transmittal time, will be required each time for review of a Submittal or Resubmittal. An additional (20) working days, exclusive of transmittal time, will be required for reviewing substitute materials or manufacturer. The review time period shall be considered by the Contractor when scheduling the work.
 - H. No equipment or material shall be used, furnished, or installed unless previously reviewed and accepted by the Architect.
 - I. Reviewed submittals on substitute equipment shall only allow the Contractor to proceed with installation. The substitution shall not be considered equal until such time as the Owner and Owner's Representative have completely accepted the installation. All costs for removal, relocation, or replacement of said Substitution shall be at the risk of the Contractor.
 - J. Regardless of any information included in the submittal submitted for review, the requirements of the Drawings and Specifications shall not be superseded in any way by the review. Review by the Architect does not relieve responsibility for submittal errors or from meeting the requirements of the Contract Documents.
- 1.10 SCHEDULE OF VALUES
- A. As part of the Submittal, provide a Schedule of Values with Unit Pricing to the Architect for approval review.

B. Schedule of Values

1. Provide a schedule of values to be approved by Owner's representative, itemizing costs by construction phase for each technology system for labor and materials, with additional breakdowns for rough and finish work by construction phases, by system.
2. The schedule of values shall be submitted for review and acceptance prior to the paying of any invoice.
3. The schedule of values shall accurately reflect the actual costs for each category, including allocation for overhead and profit.
 - a. As a minimum, provide the following breakdown, by phase where applicable, as indicated:
 - 1) Each major piece of equipment
 - 2) Other equipment by category
 - 3) Material and labor for each item.
 - 4) Equipment installation by category and each major piece of equipment.
 - a) Roughing work.
 - b) Finish work.
 - 5) Bond
 - 6) Testing.
 - 7) Owner training.
 - 8) Operation and Maintenance Manuals.
 - 9) Record drawings.

1.11 QUALITY ASSURANCE

- A. Contractor Qualifications: Manufacturer's authorized representative who is trained and approved for installation of equipment required for the work of this Section.
1. The Contractor (Firm and Employees) shall be experienced in the operations they are engaged to perform.
 2. The Contractor must provide documentation as part of the submittal process that they themselves are trained and authorized for installation of all products specified.
 3. The Contractor must customarily furnish the size, scope and nature of this Section and must be an authorized manufacturer's representative, certified (if certification programs exist with such manufacture), experienced and qualified to provide, install, program, troubleshoot, train, warrant and service all the systems in this section in their entirety.
 4. Provide documentation as part of the submittal process that the Contractor is authorized by the manufacturer(s) for products to be installed as part of this Section, and are experienced and qualified to provide, install, program, troubleshoot, train, warrant and service all systems and products specified in this Section.
 5. Provide documentation as part of the submittal process that the Contractor holds recent, up-to-date licenses and training certificates for the equipment to be installed.
 6. The Contractor must provide as part of the submittal process a list of at least five (5) projects of similar size, scope, and nature.
 - a. Provide the following information for each project:
 - 1) Name of Project
 - 2) Address
 - 3) Contact Person, Title, and Telephone Number

- B. Testing Agency Qualifications: Qualified agency, with the experience and capability to conduct testing indicated.
- C. Comply with current TIA/EIA Building Telecommunications Wiring Standards and BICSI Telecommunications Distribution Methods and Standards.
- D. Comply with NFPA 70.

1.12 INTERPRETATION OF DRAWINGS

- A. All work indicated on the Drawings is intended to be approximately correct to scale, but figures, dimensions, and detailed Drawings are to be followed in every case. The Drawings shall be taken in a sense as diagrammatic. Size of raceways and methods of running them are indicated, but it is not intended to show every offset and fitting, nor every structural difficulty that may be encountered.
- B. Locations indicated on the Drawings are approximate, and it is intended that all equipment shall be located in accordance with the general and detail Drawings of the construction proper. Coordinate the location, mounting heights, and routing of cabling work with other trades' requirements and with field conditions.
- C. All measurements shall be taken at the building before fabrication commences.
- D. Schematic diagrams shown on the Drawings indicate the required functions. Standard diagrams of the manufacturer may be used for the functions indicated without exact adherence to the Schematic Drawings shown. Work required for such deviations shall be provided.
- E. Items referred to in singular number in Contract Drawings shall be provided in quantities necessary to complete work.
- F. The right is reserved to make reasonable changes in locations of work prior to rough-in at no additional cost.
- G. Where Drawings or Specifications conflict or are unclear, advise the Architect in writing before Award of Contract. Otherwise, interpretations of Contract Documents by the Architect shall be final, and no additional compensation shall be permitted due to discrepancies or ambiguities that are resolved according to the Architect's interpretation.
- H. Drawings and Specifications form complimentary requirements. Provide work indicated on the Drawings, but not specified; and work specified, but not indicated on the Drawings as though explicitly required by both.
- I. Drawings and Specifications do not undertake to indicate every item required to produce a complete and properly operating installation. Materials, equipment, or labor that is not indicated, but that can be reasonably inferred to be necessary for a fully complete, secure, and properly operating installation suitable for the intended use, shall be provided.
- J. Drawings do not limit responsibility of determining full extent of work required by Contract Documents. Refer to all Drawings and Specifications that indicate types of construction in which work shall be installed, and work of other trades with which work of this Contract must be coordinated.
- K. Except where modified by a specific notation to the contrary, it shall be understood that the indication or description of any item, in the Drawings or Specifications or both, carries with it the

instruction to provide the item, regardless of whether this instruction is explicitly stated as part of the indication or description.

- L. Where Drawings or Specifications do not coincide with manufacturer's recommendations, or with applicable Codes and Standards, alert the Architect in writing before installation. Otherwise, make changes in installed work as the Architect requires without additional cost.
- M. It is the intent of these Contract Documents to have systems and components that are fully complete and operational, and fully suitable for the intended use. There may be situations in the documents where insufficient information exists to precisely describe a certain component or subsystem, or the routing of a component. In such cases, where the Contractor has failed to notify the Architect in writing of the situation prior to Contract Award, the Contractor shall provide the specific component or subsystem with all parts necessary for the intended use, fully complete and operational, and installed in workmanlike manner, either concealed or exposed per the design intent.
- N. In situations where potential conflict exists, or where the Contractor believes guidance is required, submit a sketch identifying proposed solution, and the Architect shall review, note if necessary, and return this sketch appropriately marked for use by the Contractor.

1.13 OBTAINING INFORMATION

- A. Obtain from the manufacturer the proper method of installation and connection of the equipment that is to be furnished or installed. Obtain all information that is necessary to facilitate the work and to complete the project. Include all such information in Operation and Maintenance Manuals.

1.14 RECORD DRAWINGS

A. Telecommunications Record/Documents

1. Submit Record Drawings for review with at least the minimum information including "required linkages", "other linkages" and "user codes" required by TIA/EIA-606 for the following:
 - a. Pathway Records
 - b. Termination Hardware Records
 - c. Space Records
 - d. Termination Position Records
 - e. Cable Records
 - f. Grounding Records
 - g. Labeling Records
2. One complete set shall be maintained at the site on which shall, at all times, accurately and clearly show the actual installations in accordance with the requirements of this SECTION.
3. At the completion of the contract provide the following for approval.
 - a. Complete set of "as-built" corrected Record Drawings.
 - b. "As-built" telecommunications drawings in hard copy and in electronic format, AutoCad 2000 or higher, with the following information.
 - 1) All telecommunications outlet locations identified.
 - a) All telecommunication identification labeling indicated for each connector in all outlets.
 - b) All Video Multi-tap locations.
 - c) All Wire Closets and Racks identified.

- c. Provide complete test reports for all cable systems.
 - d. Provide all warranty information.
4. "As-built" telecommunications drawings shall be submitted for approval prior to final inspection for acceptance of the work for each construction phase of the project.
5. Availability of approved "as-built" telecommunications drawings shall be a prerequisite for scheduling any final inspection for acceptance of the work for this SECTION.

1.15 PERMITS, FEES, RULES, AND REGULATIONS

- A. Give the proper Authorities all requisite notices or information relating to the work under this Contract. Obtain and pay for all fees, licenses, permits and certificates. Comply with the rules and regulations of all local, state, and federal authorities having jurisdiction, Building Codes, the rules and regulations of the National Board of Fire Underwriters, and the public utility companies serving the building.
- B. Public utility back charges will be paid for by the Owner and are not to be included in the base bid. Markups on utility back-charges will not be allowed.
- C. Perform work in accordance with Nationally Recognized Testing Laboratory (NRTL) listing or labeling requirements, OSHA regulations, NFPA Standards, Electrical Code, the Americans with Disabilities Act Accessibility Guidelines (ADAAG), TIA/EIA, and BICSI. The Drawings and Specifications do not attempt to indicate all work required by codes, regulations, and authorities.
- D. Nothing in these Contract Documents shall be construed to permit work not conforming to applicable codes and regulations. When conflicts occur, the more restrictive requirements shall govern.
- E. Toxicity: Comply with applicable codes and regulations regarding toxicity of combustion products used or hazardous materials used, or disposed of.
- F. Legally dispose of all material. Adhere to all regulations regarding disposal of hazardous material. Recycle hazardous material where recycling is possible. Submit certificates of legal recycling or disposal to the Architect. Include copy in the Owner and Maintenance Manual.
- G. Should the Facility have established building standards, rules, or regulations, obtain a copy from the Building Owner, and comply with them.

1.16 DELIVERY, STORAGE, AND HANDLING:

- A. Do not deliver items to the site until all specified submittals have been submitted to, and approved by, the Architect.
- B. Deliver materials in original packages, containers, or bundles bearing brand name, or identification of manufacturer or supplier.
- C. Deliver, store, protect, and handle products in accordance with recommended practices listed in Manufacturer's Installation and Maintenance Manuals.
- D. Protect materials from damage due to moisture, direct sunlight, excessive temperatures, surface contamination, corrosion, and damage from construction operations and other causes.

1.17 PROTECTION OF WORK AND PROPERTY

- A. Be responsible for the care and protection of all work included under this SECTION until it has been tested and accepted.
- B. Protect all equipment and materials from damage from all causes, including theft. All materials and equipment damaged or stolen shall be replaced with equal material or equipment at the option of the Architect and Owner.
- C. Materials and equipment stored for this project shall be protected and maintained according to the manufacturer's recommendations and requirements, and according to the applicable requirements of NFPA 70B.
- D. Protect all equipment, outlets and openings with temporary plugs, caps and covers. Protect work and materials of other trades from damage that might be caused by work or workmen, and make reparations for any damage caused.
- E. Use caution to avoid damage to existing work, and to prevent harm to personnel working in all areas.
- F. Observe all safety precautions and requirements for the construction.
- G. When open-flame or spark-producing tools, such as blower torches, and welding equipment are required in the process of executing the work, the Construction Manager shall be notified not less than twenty four hours in advance of the time that the work is to begin and the location where the work is to be performed. Provide, where necessary, fire protective covering and maintain a constant non-working fire watch where work is being performed, and until it is completed.
- H. The Construction Manager and the Cabling Contractor are responsible for initiating, maintaining, and supervising all safety precautions and requirements during construction.

1.18 MATERIAL AND EQUIPMENT STANDARDS

- A. Manufacturers: Except where no substitutions are indicated, where materials or equipment are specified by patent proprietary name or name of the manufacturer, such specification is used for the purpose of establishing a standard for that particular item. If three or more manufacturer are listed, the material and equipment shall be supplied by one of those indicated and that material and equipment shall conform in all respects to the Drawings and Specifications.
- B. Substitutions: If a substitution is offered for review, the material, equipment, or process offered for consideration must be equal in every respect to that indicated or specified. The request for each substitution must be accompanied by a letter from an Authorized Representative of the manufacturer and the Contractor, indicating that the substitution meets or exceeds all specified requirements. Include a detailed comparison of the specified item and the substitute item.
 - 1. Provide complete specifications, drawings, or samples to properly appraise the materials, equipment, or process. Acceptance of substitutions shall be based on performance, appearance, use, maintenance requirements, durability, aesthetics, physical arrangement, size, and quality.
 - 2. Provide documentation from both specified Product Manufacturer and the proposed substitute Product Manufacturer with a separate comparative analysis sheet that matches product specification item for item. Substitutes shall not be considered unless accompanied by this documentation
 - 3. Reviewed submittals on substitute equipment shall only allow the Contractor to proceed with installation. The substitution shall not be considered equal until such time as the Architect and Owner's Representative have completely accepted the installation. All costs for removal, relocation, or replacement of said Substitution shall be at the risk of the Contractor.

4. If a substitution of materials or equipment, in whole or in part, is made, bear the cost of any changes, engineering, or construction, necessitated as a result of said substitution.
- C. Materials shall be new, unused, of recent manufacture, not previously installed, full weight, standard, the best quality of its kind, and acceptable to the Architect.
- D. Provide NRTL-listed or labeled products whenever there are NRTL standards, listings, or labeling available for that product category.
- E. The Specifications or notes and description following a catalog number is basically to identify the item, but may also call for accessories, options, or modifications that are not indicated in the catalog number.
- F. No equipment or material shall be used, furnished, or installed unless previously reviewed and accepted by the Architect.

1.19 CONTINUATION OF SERVICES

- A. Maintain all existing technology system cabling and equipment for continuation of services during all construction phases.
- B. Provide all equipment, materials, cabling, and labor necessary to provide for the seamless integration of all existing and new technology systems. All additional cabling, equipment, and labor necessary to provide for continuation of services shall be included.
- C. Provide all materials, cabling, and labor necessary to make ready any temporary locations for personnel during all construction phases. All additional cabling, equipment, and labor necessary to accommodate temporary or additional locations shall be included.

1.20 SEQUENCING AND SCHEDULING

- A. Coordinate the work of this SECTION with the respective trades responsible for installing interface work, and ensure that the work performed hereunder is acceptable to such trades for the installation of their work.
- B. Refer to the overall scheduling of the work of the project. Schedule work, process Submittal and order materials and equipment to conform to this schedule, and install work to not delay nor interfere with the progress of the project.
- C. Inform Architect immediately of any delays or potential delays. Furnish manufacturer's letter to verify order date, equipment delays, expected shipment date, order number, and potential remedies to speed up delivery. Any costs to speed up delivery shall be implemented at no cost to the project if the equipment or material was not ordered as soon as possible after Contract award or within the time frames indicated with the Submittal.
- D. Include premium time required to comply with the project scheduling and phasing.
- E. Be aware of, and plan for, project scheduling and phasing. Provide for complete continuous operation of all systems. Coordinate scheduling and phasing with the Architect, Owner, other Trades, and the Construction Manager.

1.21 WARRANTY

- A. Refer to Division 1 of specifications for additional warranty requirements.

- B. Provide an installer's warranty for one year against defects in material and workmanship on all components, equipment, software, systems, and cabling specified. Warranty shall start at time of substantial completion or routine use, whichever comes first. Warranty shall include all materials, equipment, and work furnished or installed under this Section. Any failure due to defective material, equipment, installation, or workmanship that may develop shall be corrected at no expense to the Owner, including all materials, labor, travel, expenses, system diagnostics, and damage to areas, materials, and other systems resulting from such failures.
- C. Equipment manufacturers shall provide their standard replacement warranties for material and equipment furnished under this Section. Such warranties shall be in addition to and not in lieu of, all liabilities that the Manufacturer and the Installer may have by law or by provisions of the Contract Documents.
- D. Provide a Manufacturer's Structured Premises Cabling System warranty. Such warranty shall be for a minimum of twenty-five (25) years.
 - 1. The Contractor shall provide documentation that he/she is authorized and certified, and in good standing with the manufacturers and is approved to provide this manufacturer's 25-year warranty.
 - 2. The Contractor shall provide a written 25-year warranty from the manufacturer at substantial completion of the project.
 - 3. The warranty shall include connecting hardware products and installed cable as part of the structured cabling system.
 - a. The structured cabling system shall include:
 - 1) Work area outlets
 - 2) Horizontal cable
 - 3) Backbone cable
 - 4) The connecting hardware in the horizontal cross-connect
 - 5) The equipment cord at the work area outlet
 - 6) The patch cord in the horizontal cross-connect
 - 4. The manufacturer's warranty shall guarantee:
 - a. The structured cabling system shall be free from defects in materials and workmanship, for the duration of the warranty.
 - b. The structured cabling system shall support any current or future application ratified by IEEE, ANSI, ISO, designed to operate compliant with all category 5e and Category 6 drafts or standards in effect at the time of the installation, for the duration of the warranty.
 - 5. If the structured cabling system is determined to be defective within the scope of this warranty, the product found to be non-conforming shall be repaired or replaced by the manufacturer at no cost for materials or labor under this warranty.
 - 6. Include copies of all warranties, maintenance contracts, and training contracts or performance bonds in the Operation and Maintenance Manuals.

1.22 MAINTENANCE

- A. Provide an installer's annual maintenance contract quote upon request.
- B. Upon receipt of notice from the Owner of failure of any part of the systems during the warranty period, the affected parts shall be replaced. Any equipment requiring excessive service, consisting of more than two unscheduled service calls, shall be considered defective and shall be replaced.

1. Response times to warranty issues shall differ according to the level of the problem.
 2. A problem is considered to be corrected when the system and its components operate according to specified requirements.
 3. Warranty work shall be performed according to the procedures of the Owner, its staff and tenants, and their normal operations.
 4. The following levels of response to problems are required:
 - a. Major Failure: 4-hour maximum response time if notified by telephone, 24 hours per day, 365 days per year.
 - b. Minor Failure: 24 hours maximum response time if notified by telephone, 365 days per year.
 5. Failures are defined as follows:
 - a. Major Failure: a system failure that disables the entire system or major part of the system, or an individual critical piece of equipment that prevents the proper operation of more than one system component.
 - b. Minor Failure: a system failure that affects only one non-critical component and does not affect operation of any other components or any failure that is not defined as a major failure.
 - c. Major and minor failures are as defined by the Owner.
 6. Response time to a call is defined as the time at which a qualified technician arrives at the site and starts repairs or diagnostics. If the problem has not been corrected within two hours of the initial response, regional and/or national support personnel shall be contacted for assistance.
- C. Adequate stocks of parts, components, and access to regional and national support personnel shall be available such that all major failures shall be corrected within 8 hours of Owner's initial telephone call, and all minor failures within 48 hours. Temporary components may be used to meet this requirement while new components or repairs are completed. Temporary components shall be replaced with new (unused) components or the original component repaired as soon as practical. Remanufactured equipment or components are not considered new and shall not be used.
- D. Provide certified factory-trained technical service personnel for service and maintenance of the system.
1. Provide a copy of this warranty section in the Operations and Maintenance Manuals. Each copy shall be dated, signed, and certified by an authorized Representative of the Installer providing work under this Section stating that these requirements are understood and will be complied with without exception.

1.23 CERTIFICATES OF APPROVAL

- A. Upon completion of all work, and as a condition to receiving payment at Substantial Completion, furnish to the Architect the following original, signed certificates, and include copies of these certificates as part of the Operation and Maintenance manuals:
1. Certification from the manufacturer's authorized representative stating that authorized factory engineers have inspected and tested the operation of their respective equipment and found same to be installed in accordance with the manufacturer's requirements, all requirements for manufacturer's warranties are complied with, and equipment is in satisfactory operating condition. This certification shall be provided for each piece of major equipment and for all complete systems. Provide certificate for additional items requested by the Architect.
 2. Certificates of inspection, letters, or notices from the appropriate governmental authorized inspection authorities stating that all portions of the work (indicate trade and responsibility) have been inspected, and are installed in conformance with the applicable codes, laws, ordinances,

and referenced standards. If non-conformance notices are received, include the re-inspection certificate, letter of explanation as required to indicate complete conformance. Provide written evidence of all exceptions or variances given by any Inspector.

3. Certificate from the installing firm responsible for the work (indicate trade and responsibility) signed by an authorized Officer of the firm and the Foreman or Project Manager in charge, indicating trade license numbers and stating that to the best of the signer's knowledge and belief that the project (indicate project name and address) has been installed in compliance with the Contract Drawings, Specifications, and Addenda, and all applicable codes, laws, ordinances, and referenced standards. Where sub-contractors perform a portion of the work of this Section, include certificates from them.

1.24 SUBSTANTIAL AND FINAL COMPLETION

- A. Refer to General Conditions and Supplementary Conditions.
- B. Substantial Completion shall not be considered unless all systems are tested and verified for adherence with Contract Documents and any work remaining is less than one percent of the total Contract Value of this SECTION.
- C. Record Drawings, Operation and Maintenance Manuals, Acceptance Demonstrations, Owner personnel training, spare parts or extra materials required, test reports, warranties and certifications of installation inspections shall be submitted and accepted prior to Substantial Completion.
- D. Final Completion shall be when all work under the Contract is completed as defined by the Contract Documents and accepted by the Architect.
- E. Upon completion of all work under this Section, submit written certifications that:
 1. Contract Documents including addenda, clarifications, change orders, RFIs, and instructions from Architect have been reviewed.
 2. Work has been inspected for compliance with Contract Documents.
 3. Work has been completed in accordance with Contract Documents, and any deficiencies listed with Certificate of Substantial Completion have been corrected.
 4. Equipment and systems are fully operational.
 5. Work is complete and ready for Architect's final review.
 6. When Architect determines Work is complete, close out submittals will be considered.

1.25 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS

- A. At least thirty (30) days prior to Substantial Completion, submit for review one (1) sets of Operating and Maintenance (O&M) Manuals containing Manufacturer's catalogs, and other similar data, including the necessary photographic equipment cuts, wiring diagrams and final reviewed Shop Drawings and Product Data covering all equipment and devices furnished or installed under this Section. These manuals shall provide complete instructions for the proper operation and use of the equipment together with instructions for lubrication and periodic maintenance, and for trouble shooting. Operating instructions shall be specific for each system and shall include copies of posted specific instructions. This manual shall contain only information that specifically applies to this project, and all unrelated material shall be deleted or clearly crossed out.
- B. Upon approval, submit three (3) sets of the approved O&M Manuals to the Owner.
- C. The Operating and Maintenance Manual material shall be bound in 3-ring binders and indexed.

1. On the edge of the binder provide a clear see-through plastic holder with a typed card indicating the Project name, the Architect's name, the installer's name and the Volume number (e.g., Vol. No. 1 of 2).
 2. Index shall identify the page number(s) or section divider number for each item.
 3. The Owner and Maintenance Manual Index column headings shall identify the following minimum information. Manuals must be submitted using the following "headings" in the order indicated from left-to-right on the Index:
 - a. "Description" of each item
 - b. "Manufacturer's" Name for each item
 - c. Manufacturer's "Model #" for each item
 - d. Owner and Maintenance Manual "Page" Number(s) or "Section" Divider Number for each item.
- D. Provide name, address, and telephone number of the manufacturer's representative and service company for all items supplied, so that the source of replacement parts and service can be readily obtained.
1. Include copies of manufacturer's and installer's warranties and maintenance contracts, and performance bonds properly executed and signed by an authorized representative.
- E. Include copies of all test reports and certifications.
- F. Include copies of all contractor and manufacturer Warranties, including the manufacturer's 25-year structured cabling warranty.
- 1.26 SEISMIC REQUIREMENTS
- A. Equipment and work shall meet the restraint requirements for a Seismic Zone - 2 location, including installation and connections of material and equipment to the building structure.

PART 2 - PRODUCTS

2.1 OPEN-FRAME 2-POST EQUIPMENT RACKS

- A. Manufacturer: Subject to compliance with requirements, provide Middle Atlantic Model #RLA19-1245B or comparable product by one of the following-
1. Hubbell
 2. APC
 3. Chatsworth
 4. or equal
- B. Free Standing 2-Post Open-Frame Equipment Racks
1. Free standing Open-Frame equipment racks shall be seven feet (2134mm) high, EIA nineteen inches (518mm) wide, fifteen inches (381mm) deep, open bay as indicated on the Drawings. Rack features shall include the following:
 - a. Rack shall have 45 Rack Units of vertical space.
 - b. Rack shall be extruded (not sheet metal) aluminum.
 - c. Rack shall have universal hole pattern on the front and rear flanges, and mounting holes on both sides of rack assembly for management brackets
 - d. Mounting holes shall be tapped 12-24 on EIA mounting centers.
 - e. Mounting holes that require supplemental threaded clips are specifically prohibited.
 - f. UL listed load capacity shall be 400 lbs, and static weight capacity shall be 1,600 lbs., when properly loaded with base securely anchored.
 - g. Rack shall have a flat black powder coat finish.
 - h. Rack shall be GREENGUARD Indoor Air Quality Certified for Children and Schools.
 - i. Rack shall be RoHS EU Directive 2002/95/EC compliant.
 - j. Rack shall be manufactured by an ISO 9001 and ISO 14001 registered company.
 - k. Open frame rack shall be warrantied to be free from defects in material or workmanship under normal use and conditions for the lifetime of the product.
 2. Provide all hardware, supplementary steel, channel and supports as required to properly assemble the cabinet and secure it to the building structure at the top and bottom.
 3. All equipment racks and their hardware shall be properly assembled and match in appearance and shall be provided by the same manufacturer
 4. All equipment racks shall be securely fastened to building structure at top and bottom.

2.2 EQUIPMENT CABINETS

- A. Free Standing Equipment Cabinets
1. Manufacturer: Subject to compliance with requirements, provide APC, Model AR3150, or comparable product by one of the following:
 - a. Middle Atlantic
 - b. Hubbell
 - c. Chatsworth
 - d. or equal
 2. Specifications
 - a. Free Standing Equipment Cabinets shall be seven feet (2134 mm) high, 30 inches (762 mm) wide, 42 inches (1070 mm) deep, rack height 42U.

- b. Cabinets shall be welded construction, steel or aluminum, piano-hinged front and rear doors with keyed locks and access handles on front and rear. Door locks shall be keyed alike. Color shall be approved by the Architect.
- c. Cabinets shall have integral fans and louvers to adequately ventilate the equipment within the cabinets. The individual cabinet shall have adequate ventilation in order to have a temperature within the cabinet be no greater than 88 degrees F based on an ambient room temperature of 78 degrees F in the warmer months of the year and 68 degrees F in the colder months of the year.
- d. Integral EIA nineteen inch (518 mm) wide, four (4) post equipment rack. Rack shall be as described herein this specification. Rack shall be located within the cabinet in order to properly mount all passive and active electronic components.
- e. Shelves for electronic equipment with load-carrying capacity to support at least 125 percent of each piece of electronic equipment weight. Shelves shall have adequate openings within them to dissipate heat and allow for adequate electronic equipment ventilation.
- f. Mounting brackets (rails) shall be adjustable and specifically designed to support the equipment installed within the cabinet.
- g. Hook and loop (Velcro) cable strain-relief system on rear of rack to support horizontal and backbone cables. Tie-wraps are specifically prohibited.
- h. Hook and loop (Velcro) horizontal and vertical cable management on front of rack to support patch cable and cross-connect wiring. Tie-wraps are specifically prohibited.
- i. Hook and loop (Velcro) cable management system independent of telecommunications cabling management to properly dress the electronic equipment power cords through the cabinet, maintaining as much clearance between the two as possible. Tie-wraps are specifically prohibited.
- j. Bonding and grounding cables for all equipment not directly bolted to equipment rack (i.e. shelf mounted electronic equipment).
- k. Bonding and grounding bus bar with individual set screw terminals for at least six #6 Cu. bonding cables.
- l. Surge protected power strip as described in this specification.
- m. Patch panels as described in this specification.
- n. Blank/louvered panels, where required, to fill gaps between equipment within the rack.
- o. All hardware, supplementary steel, channel and supports as required to properly assemble the cabinet and secure it to the building structure.
- p. All equipment cabinets and their hardware shall be properly assembled and match in appearance and shall be provided by the same manufacturer.
- q. All rack-mountable equipment shall be installed utilizing tamper-proof screws into an equipment cabinet.

B. Roll Out Rotating System Cabinet

- 1. Manufacturer: Middle Atlantic, model # WR-44-42, or approved equal.
- 2. Specifications
 - a. EIA compliant 19" roll out rotating system in steel host enclosure.
 - b. Overall Dimensions: 88.86 in. H x 42.875 in. D
 - c. Maximum Rollout: 35 in.
 - d. Rotation Angle: 30 degrees
 - e. Rack shall be of fully welded construction
 - f. Weight capacity shall be 750 lbs. when 1/2 of total equipment weight is mounted in lower 1/3 of the rack
 - g. Rack shall be constructed of the following materials: top and bottom (rack and outer frame) and roller carriage shall be 14-gauge steel; side panel and horizontal braces shall be 16-gauge steel
 - h. Rackrail shall be constructed of 11-gauge steel with tapped 10-32 mounting holes in universal EIA spacing with black e-coat finish and marked rackspace

- i. Rack shall have removable split rear knockout panels with 1/2", 3/4", 1" & 1-1/2" electrical knockouts installed in base and removable split rear knockout panels with 1/2", 3/4", 1" & 1-1/2" electrical knockouts
- j. Knockouts on sides to accommodate 4" electrical conduit and cable pass-through
- k. Rack shall be UL Listed in the US and Canada. Rack shall be GREENGUARD Indoor Air Quality Certified for Children and Schools
- l. Rack shall be RoHS EU Directive 2002/95/EC compliant
- m. Rack shall be manufactured by an ISO 9001 and ISO 14001 registered company
- n. Rack shall be warranted to be free from defects in material or workmanship under normal use and conditions for a period of three years
- o. Front door shall be solid 16-gauge steel
- p. Integrated fan top shall include a proportional speed thermostatic fan control and (4) 4-1/2" quiet fans

3. For proper cable management, adjust lacer bars on rack frame and host enclosure as needed.

C. Wall Equipment Cabinets

1. Manufacturer: Middle Atlantic, Model # DWR-24-32, or comparable product by one of the following:

- a. Hubbell
- b. Chatsworth
- c. Cooper
- d. or equal

2. Specifications:

- a. EIA compliant 19"
- a. Overall dimensions shall be 23.44" W x 49" H x 32.3" D.
- b. Rack shall have a 30" useable depth.
- c. Rack shall be of fully welded construction.
- d. Rack shall be constructed to swing open for component cabling access, center section shall pivot for either left or right opening.
- e. Rack shall have a rear knockout panel with 1/2", 3/4", 1", 1-1/2", 2" and 3" electrical knockouts installed in base, and a rear knockout panel with 1/2", 3/4", 1", 1-1/2", 2" and 3" electrical knockouts, four Decora® cutouts, and BNC knockouts for UHF/VHF antennas installed in top.
- f. Large laser knockout on back pan shall have a 12-1/2" x 12-1/2" cutout for electrical pull-box.
- g. Rack front door shall be solid reinforced 16-gauge steel.
- h. Rack shall have a keyed lock.

D. Equipment cabinets with cables entering from above shall have enclosed square raceway to above ceiling. Raceway shall be code gauge steel, sized per code, attached and terminated at equipment cabinet and building structure with approved bushed terminations. Raceway shall be painted to match equipment cabinets.

2.3 CABLE MANAGEMENT

A. Horizontal cable management for equipment racks and cabinets shall be EIA 19-inch (518mm) rack mounted 3.5 inch (88mm) high panel with 6" deep horizontal and vertical patch cable distribution rings.

1. Horizontal wire management shall be provided above and below each patch panel.
2. Coordinate with the Owner for the quantity of additional horizontal wire management panels required for equipment provided by the Owner.
3. Horizontal cable management shall be furnished by the patch panel manufacturer.

- B. Vertical cable management for equipment racks shall be 6-inches (152.4mm) wide, seven feet (2134mm) high, 14 ga. cold rolled steel with covers, mounted on each equipment rack rail.
 - 1. Vertical cable management shall be furnished by equipment rack manufacturer.
- C. Cable management for IDC-Type, cross-connect blocks shall be multiple distribution rings. Multiple distribution rings shall be provided above and below all cross-connect blocks.

2.4 RACK MOUNT SURGE PROTECTIVE DEVICE (SPD)

- A. Manufacturer: Leviton 5500-192, NEMA 5-20A, straight blade plug or comparable product by one of the following:
 - 1. Great Lakes 7219-20AR
 - 2. Surge-X-20A
 - 3. or equal
- B. Specifications
 - 1. Surge-protected power strip shall be rack-mount type.
 - 2. Ten NEMA 5-20R outlets in back and two in the front
 - 3. LED diagnostics for power, protection, and outlet polarity/ground status
 - 4. 12-foot power supply cord
 - 5. Rated Line Voltage 120V
 - 6. Max. Load Current 20A
 - 7. Max. Continuous Operating Voltage 135V
 - 8. Operating Frequency Range 50/60Hz
 - 9. Circuit Type Staged-Multi Component Series
 - 10. Max. Single-Pulse Transient Current 33,000A
(8x20 μ s, Amps peak)
 - 11. Peak Surge Current 72kA
 - 12. EMI/RFI Noise Rejection @ 100 Hz - 30 MHz 10 to -35dB
 - 13. Cat. A Ringwave (6kV, 200A, 100kHz) 190V
 - 14. Cat. B Ringwave (6kV, 500A, 100kHz) 210V
 - 15. Cat. B Impulse (6kV, 3kA, 8x20 μ s) 310V
 - 16. Clamping Voltage (8x20 μ s @ 500A) 330V
 - 17. UL 1363 Relocatable Power Taps, UL Recognized Component {E118936}
 - 18. ANSI/UL 1449 Surge Protective Devices, UL Recognized Component, Type 4 SPD evaluated for use in Type 3 applications {E317603}
 - 19. 1.75" x 19.00" x 4.55" (H x W x D)
- C. Provide two surge protective devices for each rack and cabinet installed.

2.5 WORK AREA OUTLETS

- A. Data network Work Area Outlet modular connectors shall exceed all application performance requirements for Category 6 per the TIA/EIA-568-B and 568-C Series standards.
- B. Manufacturer: Subject to compliance with requirements, provide products from one of the following:
 - 1. Belden
 - 2. Hubbell
 - 3. Ortronics

4. Panduit
5. Seimon

C. Each Work Area Outlet shall consist of the following:

1. Single-gang or dual-gang faceplate shall be thermoplastic (nylon) with number of voice, data, video, and sound jacks as indicated in the Specifications and Drawings.
 - a. All thermoplastic (nylon) faceplate colors shall be by Architect.
 - b. All faceplates in the Gymnasium(s) and Cafeteria(s) shall be stainless steel.
 - c. All faceplates shall have recessed windows with clear plastic covers for labels. Use of surface mounted adhesive labels is prohibited.
2. Electrical Contractor shall provide 4" square, minimum 2-1/8" deep, back boxes for all Single-gang and Dual-gang outlet faceplates. Electrical Contractor shall provide single-gang and dual-gang plaster rings for the specified Single-gang and Dual-gang outlet faceplates. Electrical Contractor shall provide all blank faceplates for standard gang boxes.

D. Surface-Mount Raceways:

1. Single-gang Work Area Outlets: For areas that use surface-mount raceway and require single-gang work area outlets, the faceplates shall be a single-gang faceplate, have a separate full size single-gang opening/bracket to accommodate all outlets.
 - a. Faceplates shall be horizontally mounted and filled with applicable modular connectors for the designated symbol and include blanks to accommodate future faceplate expandability.
 - b. Faceplates shall be thermoplastic (nylon) or stainless steel and have recessed windows with clear plastic covers for labels. Use of surface mounted adhesive labels is prohibited.
2. Multi-gang Work Area Outlets: For areas that use surface-mount raceway and require multi-gang work area outlets, the faceplates shall be single-gang faceplates in quantities as required. Each faceplate shall have a separate full size single-gang opening/bracket to accommodate all outlets.
 - a. Faceplates shall be horizontally mounted and filled with applicable modular connectors for the designated symbol and include blanks to accommodate future faceplate expandability.
 - b. Faceplates shall be thermoplastic (nylon) or stainless steel and have recessed windows with clear plastic covers for labels. Use of surface mounted adhesive labels is prohibited.

E. Data Network Work Area Outlets:

Type DX (D28 16 001, D2, D3, D4, D5, D6) Data Work Area Outlet - shall consist of one, two, three, four, five, or six modular Category 6e RJ-45 connectors mounted on a single-gang faceplate, with the capabilities listed below. Provide blanks for faceplate, as required. Faceplate color to be approved by Architect.

- a. Each RJ-45, 8-position connector shall be provided with 4-pair Category 6e unshielded twisted pair cable as noted in the following sections:
 - 1) The RJ-45 connectors shall be used for data and cabled to relevant IDF/ICER or MDF/MCER data patch panel with 4-pair Category 6e unshielded twisted pair cable.

1. Type (TD2) Tel/Data Work Area Outlet - shall consist of three modular Category 6e RJ-45 connectors mounted on a single-gang faceplate, with the capabilities listed below. Provide blanks for faceplate as required. Faceplate color to be approved by Architect t.
 - a. The three RJ-45, 8-position connectors shall be provided with three 4-pair Category 6e unshielded twisted pair cables as noted in the following sections:
 - 1) Two RJ-45 connectors shall be used for data and cabled to relevant IDF/ICER or MDF/MCER data patch panel with one (1) 4-pair Category 6e unshielded twisted pair cable.
 - 2) One RJ-45 connector shall be used for POTS line (Fax/Modem) and cabled to relevant IDF/ICER or MDF/MCER separate voice patch panel with one (1) 4-pair Category 6e unshielded twisted pair cables and cross connected to the telephone DEMARC in the Head End Room.
2. Type VoIP Wall Telephone Outlet – Shall consist of a modular Category 6e RJ-45 connector mounted on a single-gang stainless steel faceplate at 48" A.F.F. Faceplate color to be approved by Architect
 - a. One RJ-45 connector shall be used for VoIP (data) and cabled to relevant IDF/ICER or MDF/MCER data patch panel with one 4-pair Category 6e unshielded twisted pair.
 - 1) Faceplate shall have minimum 6" clearance O.C. from adjacent items (door jambs, wall mounted frames, switches, or sensors).
3. Type (DPI) Door Phone Intercom - Shall consist of a modular Category 6e RJ-45 connector in a single-gang back box at 48" A.F.F. Provide cable, connector, and terminations. Leave 24-inch service loop within back box.
 - a. The RJ-45 connector shall be used for the door phone intercom device and cabled to relevant IDF/ICER or MDF/MCER data patch panel with one (1) 4-pair Category 6e unshielded twisted pair cable and cross connected to the telephone DEMARC in the Head End room.
 - 1) Door phone intercom device and interface to the voice/phone system will be provided by the Owner under separate contract.
4. Type (WAP) Above Ceiling Mounted Wireless Access Data Point – Shall consist of two modular Category 6e RJ-45 connectors mounted on a single-gang faceplate mounted above ceiling as Indicated on Drawings.
 - a. The two RJ-45, 8-position connectors shall be provided with 4-pair Category 6e unshielded twisted pair cables.
 - 1) The RJ-45 connectors shall be used for data and cabled to relevant IDF/ICER or MDF/MCER data patch panel with a 4-pair Category 6e unshielded twisted pair cables.
5. Type (WAP) Flush Wall Mounted Wireless Access Data Point – Shall consist of two modular Category 6e RJ-45 connectors mounted on a single-gang faceplate mounted on wall as Indicated on Drawings. Provide blanks for faceplate as required. Faceplate color to be approved by Architect.
 - a. The two RJ-45, 8-position connectors shall be provided with 4-pair Category 6e unshielded twisted pair cables.

- 1) The RJ-45 connectors shall be used for data and cabled to relevant IDF/ICER or MDF/MCER data patch panel with a 4-pair Category 6e unshielded twisted pair cable.

- b. WAP wall outlets are associated with (WE) Wireless Access Enclosures as indicated on the drawings.

F. Voice (POTS) Outlets

1. Type Desk Telephone Outlet – Shall consist of a modular Category 6e RJ-45 connector mounted on a single-gang faceplate at 18" A.F.F. Provide blanks for faceplate as required. Faceplate color to be approved by Architect.
 - a. The RJ-45 connector shall be used for POTS line (phone or Fax/Modem) and cabled to relevant IDF/ICER or MDF/MCER separate voice patch panel with 4-pair Category 6e unshielded twisted pair cable and cross connected to the telephone DEMARC in the Head End room.

G. Local Control Outlets

1. Type (C2) Control Outlet – Shall consist of two modular Category 6e RJ-45 connectors mounted on a single-gang faceplate. Faceplate color to be approved by Architect
 - a. The two RJ-45, 8-position connectors shall be provided with 4-pair Category 6e unshielded twisted pair cables as required.
 - 1) The two RJ-45 connectors shall be home-run to the associated Aggregate Control Outlet.

H. Security and Building Systems Data Outlets

1. Type (CCTV) Above Ceiling CCTV Data Outlet – Shall consist of a modular Category 6e RJ-45 connectors mounted on a single-gang faceplate mounted above ceiling as Indicated on Drawings.
 - a. The RJ-45, 8-position connector shall be provided with 4-pair Category 6e unshielded twisted pair cables as required.
 - 1) The RJ-45 connector shall be used for data and cabled to relevant IDF/ICER or MDF/MCER and terminated on a separate security/building systems data patch panel with a 4-pair Category 6e unshielded twisted pair cable.
2. Type (CCTV) Flush Wall Mounted CCTV Data Outlet – Shall consist of a modular Category 6e RJ-45 connector mounted on a single-gang faceplate mounted in wall as Indicated on Drawings. Coordinate exact location and elevation with Architect and Security Contractor prior to installation. Faceplate color to be approved by Architect
 - a. The RJ-45, 8-position connector shall be provided with 4-pair Category 6e unshielded twisted pair cables as required.
 - 1) The RJ-45 connector shall be used for data and cabled to relevant IDF/ICER or MDF/MCER and terminated on a separate security/building systems data patch panel with a 4-pair Category 6e unshielded twisted pair cable.
3. Type SX (S1, S2, S3, S4, S5, D6) Data Work Area Outlet - shall consist of one (1), two (2), three (3), four (4), five (5), or six (6) modular Category 6e RJ-45 connectors mounted on a single-gang

faceplate, with the capabilities listed below. Provide blanks for faceplate, as required. Faceplate color to be approved by Architect.

- a. Each RJ-45, 8-position connector shall be provided with 4-pair Category 6e unshielded twisted pair cable:
 - 1) The RJ-45 connectors shall be used for data and cabled to relevant IDF/ICER or MDF/MCER and terminated on a separate security/building systems data patch panel with 4-pair Category 6e unshielded twisted pair cable.
4. Type (VAPE) Vape Detection Data Work Area Outlet - shall consist of two (2) modular Category 6e RJ-45 connectors mounted on a single-gang faceplate above ceiling, with the capabilities listed below. Provide blanks for faceplate, as required. Faceplate color to be approved by Architect.
 - a. Each RJ-45, 8-position connector shall be provided with 4-pair Category 6e unshielded twisted pair cable:
 - 1) The RJ-45 connectors shall be used for data and cabled to relevant IDF/ICER or MDF/MCER and terminated on a separate security/building systems data patch panel with 4-pair Category 6e unshielded twisted pair cable.
 - 2) Vape Detection Sensors will be provided by the Owner under a separate contract.
5. Type GDS Data Work Area Outlet - shall consist of two (2) modular Category 6e RJ-45 connectors mounted on a single-gang faceplate above ceiling, with the capabilities listed below. Provide blanks for faceplate, as required. Faceplate color to be approved by Architect.
 - b. Each RJ-45, 8-position connector shall be provided with 4-pair Category 6e unshielded twisted pair cable:
 - 1) The RJ-45 connectors shall be used for data and cabled to relevant IDF/ICER or MDF/MCER and terminated on a separate security/building systems data patch panel with 4-pair Category 6e unshielded twisted pair cable
6. Type (VES, AES, and VMS) Video/Audio Entrance, Audio Entrance, and Video/Monitor/Handset Stations – Cabling shall consist of a modular Category 6e RJ-45 connector in a single-gang back box. Provide cable, connector, and terminations. Leave 24-inch service loop within back box. Coordinate exact location and elevation with Architect and Security Contractor prior to all work
 - a. Each RJ-45, 8-position connector shall be provided with 4-pair Category 6e unshielded twisted pair cable:
 - 1) The RJ-45 connectors shall be used for data and cabled to relevant IDF/ICER or MDF/MCER and terminated on a separate security/building systems data patch panel with 4-pair Category 6e unshielded twisted pair cable.
 - b. Active equipment (Video/Audio Entrance, Audio Entrance, and Video/Monito / Handset Stations) shall be provided under Section 28 16 00.
- I. Local Instructional Audiovisual Presentation System Outlets
 1. Type (VPH) High Video Presentation Outlet for Interactive Projectors and Interactive Flat Panel Displays - Shall consist of modular connectors mounted on a metal two-gang faceplate with a single

circular opening for audio speaker cable pass-through and engraved labels with the capabilities listed below.

- a. Two RJ-45, Category 6e 8-position connectors for data and cabled to relevant IDF/ICER or MDF/MCER patch panel with 4-pair Category 6e unshielded twisted pair cables.
 - b. One RJ-45, Category 6A 8-position connector with Category A shielded cable homerun to associated RJ-45 connector in associated VPL outlet.
 - c. One HDMI (2.0 or latest version) high performance cable and connector homerun to associated HDMI connector in associated LVP outlet.
 - d. Interactive projectors and Interactive Flat Panel Displays will be provided by the Owner under a separate contract.
2. Type (VPL) Low Video Presentation Outlet for Interactive Projectors and Interactive Flat Panel Displays - Shall consist of modular connectors mounted on a metal two-gang faceplate with a decora hole-cut and engraved labels with the capabilities listed below.
 - a. One RJ-45, Category 6A 8-position connector with Category A shielded cable homerun to associated RJ-45 pass-through connector in associated VPH outlet.
 - 1) Category 6A cable shall be terminated and left coiled in the back box.
 - b. One HDMI (2.0 or latest version) high performance cable and connector homerun to associated HDMI connector in associated HVP outlet.
 - c. One 3.5mm mini stereo connector and audio cable homerun to associated 3.5mm mini stereo connector in associated HVP outlet.
 - d. Interactive projectors and Interactive flat Panel displays will be provided by the Owner under a separate contract.
3. Types (AWS) and (PWS) Active and Passive Wall Speaker Outlets – Shall consist of empty single-gang back boxes with single receptacle wall plate with single circular opening for audio speaker cable pass-through.
 - a. Wall speakers will be provided by the Owner under separate contract.
4. Type (VH) High Video Outlet for Digital Signage TV Monitors – Shall consist of a modular Category 6e RJ-45 connector mounted on a single-gang faceplate mounted at 96" A.F.F. or as Indicated on Drawings. Provide blanks for faceplate as required. Faceplate color to be approved by Architect.
 - a. The RJ-45, 8-position connector shall be provided with a 4-pair Category 6e unshielded twisted pair cables as required.
 - 1) The RJ-45 connector shall be used for data and cabled to relevant IDF/ICER or MDF/MCER data patch panel with a 4-pair Category 6e unshielded twisted pair cable.
 - b. Digital Signage TV Monitors will be provided by the Owner under a separate contract.
5. Type (VCE) Ceiling Video Outlet for Digital Signage TV Monitors – Shall consist of two modular Category 6e RJ-45 connectors mounted on a single-gang faceplate mounted on ceiling. Provide blanks for faceplate as required. Faceplate color to be approved by Architect.
 - a. Two RJ-45, 8-position connectors shall be provided with 4-pair Category 6e unshielded twisted pair cables as required.
 - 1) The RJ-45 connectors shall be used for data and cabled to relevant IDF/ICER or MDF/MCER data patch panel with a 4-pair Category 6e unshielded twisted pair cable.

- 2) Digital Signage TV Monitors will be provided by the Owner under a separate contract.
6. Type (FO) Video Camera Outlet - Shall consist of optical fiber runner cable with HDMI flying transmitter and receiver leads mounted on a metal single-gang faceplate with engraved labels with the capabilities listed below.
 - a. The optical fiber cable shall be home-run to the equipment enclosure in the TV Studio Control Room.
7. Type (VPO) Video Projector Outlet – Shall consist of an empty single-gang back box on ceiling or structure. Provide stainless steel blank faceplate.
 - a. Video projectors shall be provided by under Section 27 41 01.
- J. Wireless Access Point Enclosure Symbols
 1. Type (WE) Wireless Access Point Wall Enclosure.
 - a. Provide nonmetallic Enclosure with clear cover by Oberon, or equal, for present or future wireless access points.
 - 1) Mount Enclosure directly over WAP outlet.
 - b. Coordinate with Owner on expected access points for proper enclosure prior to ordering.
- K. The color of all faceplates and modules shall be as directed by the Architect unless otherwise indicated. Faceplates shall have squared corners and shall be same dimension as the electrical outlet plate. Oversized plates are specifically prohibited.
- L. Each faceplate shall be able to support the jack modules, as required. All openings remaining after required number of jack modules have been installed in faceplates shall be blanked off with manufacturer-provided blank modules.
- M. Manufacturer and Contractor Company logo, signage, or any advertisement shall not be permitted on face of Work Area Outlets.
- N. Work Area Outlets shall have cable strain relief for each cable terminated. Cables shall not rely on the conductor termination for support.

2.6 CABLE SUPPORTS

- A. Manufacturer: Provide products meeting the requirements of the Drawings and Specifications from one of the following manufacturers:

J-Hooks:	B-Line, Caddy, Panduit
Hook and Loop Fasteners:	Chatsworth, Ortronics, Siemens.
Cable Ties:	DEK, Panduit, Amp, 3M, T&B.
Beam Clamps:	B-Line, Burndy, Steel City.
Split Mesh Strain Reliefs (Kellums):	Hubbell, Cooper, Woodhead.

- B. J-Hooks shall be sized to correctly support the number of cables that pass through them. Fill capacity shall be as required by code for conduit. That is to say that every J-Hook shall have a maximum of 40 percent fill capacity. Install additional supports as required.
- C. Hook and loop fasteners shall be designed for their specific application. For example, if a hook and loop fastener is used to support cables to a rack; it shall have a grommated outlet for use with a 10-32 rack mounting screw.
- D. Cable-ties shall be correctly sized to support the quantity and types of cables installed.
- E. Beam clamps shall be steel with threaded bolt type closure. Spring steel or "quick-clip" type clamps are prohibited.
- F. Split mesh strain-relief shall be properly sized for each cable that they support. Only one cable shall be installed in each split mesh strain-relief.

2.7 BONDING AND GROUNDING JUMPER CABLE

- A. Provide proper cable and termination of Bonding and Grounding Jumper Cable to all Equipment Racks, Equipment Cabinets and other equipment.
- B. Manufacturer: Provide products meeting the requirements of the Drawings and Specifications from the following manufacturers or an approved equal:
 - 1. Belden (No. 8669)
- C. Jumper cable shall be hollow-braided, 60-amp capacity copper.
- D. Provide equal conductor as described in "B" above for aluminum equipment.
- E. Jumpers shall have compression or exothermic-type terminals on both ends of cables. Terminals shall be compatible with jumper cable material and equipment material in order to not have any degenerative reaction.

2.8 UNSHIELDED TWISTED PAIR (UTP) CABLING SYSTEMS

- A. Voice and Data horizontal cabling: Cable shall be Category 6e (ENHANCED), 23AWG and exceed Commercial Building Telecommunications Cabling Standard ANSI/TIA/EIA-568-C.2 for Category 6.
 - 1. UTP cable shall be designed for multimedia supporting handling voice, video, and data simultaneously.
 - 2. UTP Cable shall support 10BASE-T through 1000BASE-T Ethernet, Power over Ethernet (PoE) – IEEE 802.3af, PoE+ – IEEE 802.3at Type 1 and 2, ATM and token ring, and support legacy protocols and applications
 - 3. UTP Cable shall be manufacturer tested and verified with electrical characteristics Characterized to 500 MHz or higher.

a. Minimum Characteristics

Minimum Return Loss (dB):

Frequency (MHz)	1 to 10 MHz	10 to 20 MHz	20 to 500 MHz
Return Loss (dB) - Min.	20+6 Log (F)	26	26 – 5 Log (F/20)

Frequency (MHz)	1	4	8	10	20	100	250	350	400	500	600
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RL (dB) minimum	20.0	23.6	25.4		26		22.5	20.5	19.8	19.5	19.0	18.6
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Input Impedance (Ohms):

Frequency Range from:	1 to 100 MHz	100 to 500 MHz
Input Impedance (Ohms)	100 \square \pm 13%	100 \square \pm [13+15Log(F/100)]%

Frequency (MHz)	1	4	10	16	20	31.25	62.5	100	250	350	400	500	600
Input Impedance (Ohms) min.	87								81.0	78.8	78.0	76.5	75.3
Input Impedance (Ohms) max.	113								119.0	121.2	122.0	123.5	124.7

Maximum Attenuation (dB/100 m):

Frequency (MHz)	1	4	10	16	20	31.25	62.5	100	250	350	400	500	600
Attenuation (dB/100 m)	2.0	3.7	5.8	7.4	8.2	10.4	15.0	19.3	32.0	38.7	41.8	47.6	53.0

Minimum Near-end Crosstalk (NEXT) and Power Sum Near End Crosstalk (PS-NEXT) Loss of any Pair Combination (dB):

Minimum NEXT Loss (dB) from .772 to 500 MHz	86 - 15 Log (F/0.772)
Minimum PS-NEXT Loss (dB) from .772 to 500 MHz	84 - 15 Log (F/0.772)

Frequency (MHz)	1	4	10	16	20	31.25	62.5	100	250	350	400	500	600
NEXT (dB) min.	84.3	75.3	69.3	66.3	64.8	61.9	57.4	54.3	48.3	46.2	45.3	43.8	42.6
PS-NEXT (dB) min.	82.3	73.3	67.3	64.3	62.8	59.9	55.4	52.3	46.3	44.2	43.3	41.8	40.6

Minimum Attenuation to Power Sum Crosstalk Ratio (PS-ACR) (dB for 100 m)

Frequency (MHz)	1	4	10	16	20	31.25	62.5	100	250	350
PS-ACR (dB) minimum @ 100 m	80.3	69.6	61.5	56.9	54.6	49.5	40.4	33.0	14.4	5.4

Minimum Equal Level Far-end Crosstalk (ELFEXT) and Power Sum Equal Level Far-end Crosstalk (PS-ELFEXT) Loss of any Pair Combination (dB for 100 m):

Minimum ELFEXT (dB) from 1 to 400 MHz	79 - 20 Log (F/0.772)
Minimum PS-ELFEXT (dB) from 1 to 400 MHz	76 - 20 Log (F/0.772)

Frequency (MHz)	1	4	10	16	20	100	250	350	400	500	600
ELFEXT (dB) minimum	76.8	64.7	56.8	52.7	50.7	36.8	28.8	25.9	24.7	22.8	21.2
PS-ELFEXT (dB) minimum	73.8	61.7	53.8	49.7	47.7	33.8	25.8	22.9	21.7	19.8	18.2

Minimum Longitudinal and Transverse Conversion Loss (LCL & TCL) (dB for 100 m):

Frequency Range (MHz)	1 to 250 MHz
Minimum LCL & TCL (dB) from 1 to 250 MHz.	40 - 10 Log

Frequency (MHz)	1	4	10	16	31.25	62.5	100	200	250	350	400	500	600
LCL & TCL (dB) minimum	50.0	44.0	40.0	38.0	35.1	32.0	30.0	27.0	26.0	24.6	24.0	23.0	22.2

Minimum Equal Level Transverse Conversion Transverse Loss (EL TCTL) (dB for 100 m):

Frequency Range (MHz)	1 to 30 MHz					
Minimum EL TCTL (dB) from 1 MHz to 30 MHz.	35 - 20 Log (F)					

Frequency (MHz)	1	4	10	16	20	30
EL TCTL (dB) minimum	35.0	23.0	15.0	10.9	9.0	5.5

Maximum Propagation Delay (ns at 100 m):

Frequency (MHz)	1	4	10	16	20	25	31.25	62.5	100	200	250 - 500	600
Propagation Delay (ns)	570	552	545	543	542	541	540	539	538	537	536	535

Mutual Capacitance: 4.4 nF/100 m nominal; 5.6 nF/100 m maximum at 1 kHz.

Maximum Capacitance Unbalance (Pair-to-Ground) at 1 kHz: 330 pF/100 m.

Maximum Conductor DC Resistance: 9.38 Ω /100 m.

DC Resistance Unbalance of a Pair: 5% Maximum, 1% Nominal.

Time Delay Skew: 35 nsec/100 m nominal; 45 nsec/100 m maximum.

Nominal pair velocity of propagation: 72%

4. Manufacturer: Provide Category 6 Enhanced products meeting the requirements of the Drawings and Specifications from one of the following manufacturers:

Wire and Cable: Belden, Data twist 4800 Series Category 6 ENHANCED
Berk-Tek, LANmark 2000 Premium Category 6
General Cable, GenSPEED 6500 Premium
Mohawk, GigiaLAN
Superior Essex, NetGain Category 6eX

Patch Cables: Shall be provided by wire and cable manufacturer.

Patch Panels: Hubbell, Leviton, Ortronics, Panduit, Siemon

Work Area Outlets: Hubbell, Leviton, Ortronics, Panduit, Siemon

Modular Jacks: Shall be provided by the Work Area Outlet manufacturer.

Cable Management: Shall be provided by patch panel manufacturer.

NOTE: Each of the products listed above shall be provided by a single manufacturer.

Voice/Phone Punch Block: AT&T, Hubbell, Leviton, Siemon

B. Category 6e Horizontal Cable -Voice and Data

1. Provide and terminate cabling from each station location to applicable IDF/ICER or MDF/MCER locations.
2. Data & Voice Cable shall be 23AWG Category 6e Unshielded Twisted Pair (UTP) as specified.
3. Cable Jackets.

- a. Plenum-rated cable - CMP rated jacket for Plenum applications.
 - b. Riser-rated cable - CMP rated jacket for Riser applications.
 4. UTP Pin/pair Termination Assignment: The UTP cabling systems shall have ANSI/TIA/EIA-586-B Series standard pin/pair termination assignment. All conductors provided shall be properly and consistently terminated at both ends throughout the entire system.
- C. Backbone Cable - Voice
1. Voice Backbone Cable shall be Category 5e, 24 AWG, 25-pair cable from the same manufacturer as the Category 6e cable.
 2. Provide one (1) Category 5e, 24 AWG, 25-pair cable from the MDF/MCER Head End to each IDF/CER wire closet.
 3. Terminate all pairs on Voice Patch Panels as specified.
- D. T1 Cable –Voice and Data Head End
1. Provide two (2) T1-specific cable and jack, one (1) for voice and one (1) for data, from Entrance Protection/Demarcation location (Smart Jack w/ RJ48S) to MDF/MCER RJ48S Jack for interface to Voice and Data systems.
 - a. Confirm with Owner type of connector required before installation.
 2. Provide and terminate cable/jack from the MDF/MCER RJ48S Jack to applicable network voice and data equipment head end rack T1 RJ48S Jack location.
 - a. Cable shall meet or exceed specifications for AVAYA T1 Cable #107503583, designed specifically for T1 Transmissions.
 - b. Plenum-rated cable - CMP rated jacket for Plenum applications.
 - c. Riser-rated cable - CMR rated jacket for Riser applications.
- E. Elevator Telephone Cabling
1. Provide two (2) Category 6e Unshielded Twisted Pair (UTP) cables from the DEMARC to each Elevator Machine Room's applicable equipment head end rack location.
 - a. Plenum-rated cable - CMP rated jacket for Plenum applications.
 - b. Riser-rated cable - CMR rated jacket for Riser applications.
 2. Terminate the cable at the DEMARC on the same type termination hardware as the voice risers.
 - a. Elevator Subcontractor shall terminate cabling at elevator control room head end.
 3. Elevator Subcontractor shall provide and terminate applicable cabling between each elevator control room and each elevator telephone location.
- F. Horizontal Cable and Jack Colors:
1. Provide horizontal cables and jacks in colors as follow.

Horizontal Cabling and Jacks	Color
Data / VoIP Cables and Jacks	Blue

Data Access Point Cables and Jacks	Yellow
Voice (POTS) Cables and Jacks	White
CCTV Cables and Jacks	Green

G. Modular Jacks (Work Area Outlets)

1. Jacks shall be Category 6e with printed circuit board technology and integral board-mounted, color-coded, high density, IDC-type terminations. Provide 8-position modular jacks. Keyed jacks are not allowed. Jacks shall be able to withstand at least a minimum of 2,000 mating cycles without any transmission degradation.
2. Each Work Area Outlet and modular jack shall have jack opening dust cover. Modular jacks that do not have integral dust covers shall have dust covers installed on each unused modular jack.
3. Each 8-position modular jack shall be uniquely color-coded for its use.
4. Modular jacks that allow pre-connectorized cables to be connected to the jacks are specifically prohibited. Cables shall have single point IDC Type connection to the jacks only.
5. Modular jacks for Work Area Outlets shall be integral to a jack module either having one or two jacks per module. Single jacks shall be located in the center of the module while double jacks shall be side-by-side horizontally. Jack modules with a single jack and a blank in the opening where a second jack would normally be located are specifically prohibited.
6. Jack modules shall be flame retardant thermoplastic with integral cable strain relief. Color shall match faceplate.

H. Patch Panels (Cat 6e) –Data and Voice

7. Patch panels shall be EIA 19-inch (518mm), rack mounted, Category 6e patch panels with integral printed circuit board, color-coded, high density, IDC type terminations and 8-position modular jacks. Keyed port connectors are not allowed. Port connectors shall be able to withstand at least a minimum of 2,000 mating cycles without any transmission degradation.
 - a. Provide high density rack mounted patch panels.
 - b. Modular port connectors that allow pre-connectorized cables to be connected to the rear of the ports are specifically prohibited. All horizontal cables shall be punched to a single point IDC-type connection on the rear of each port connector only.
 - c. Each port shall have color-coded identification label. Continuous label strips for multiple in-line ports are acceptable. Silk screened identifiers "I" through "96" are acceptable.
 - d. Patch panel shall have horizontal strain relief bar mounted on rear.
 - e. Provide Quantities as Required.
 - f. Cable management shall be provided above and below each patch panel.
8. Data Network, Security/Building Systems, and POTS Voice cables shall be terminated on separate Ethernet Data LAN, Security/Building Systems LAN, and POTS Voice patch panels in each wire closet.

I. Patch Cables and Line (Station) Cords

1. Patch cables and line cords shall be factory pre-connectorized, Cat 6e 4-UTP, 8-position modular jack, stranded conductors. Patch cables and line cords shall be able to withstand at least a minimum of 2,000 jack-mating cycles without any transmission degradation.

J. Cross Connect Blocks – Voice

1. Category 5e:

- a. Cross-connect blocks shall be TIA/EIA Category 5e (UL Category 5e) color-coded, high density, IDC-type terminations, 100 pair, cross-connect blocks. Type-66 IDC cross connect blocks or similar are not allowed. Cross-connect blocks shall have integral stand-off brackets.
- b. Cables shall have single point IDC-type connection to the cross-connect blocks only.
- c. Each (4-pair) connection shall have a color-coded identification label. Continuous label strips for multiple in-line terminations are acceptable.
- d. Provide with horizontal and vertical cable management.
- e. Provide and terminate for all horizontal and backbone voice cabling on Cross-connect blocks.
- f. Provide and terminate cables from Entrance Protection / Demarcation location to MDF/MCER for voice on Cross-connect blocks.
- g. In IDF Rooms that use Equipment Cabinets, provide / terminate Type-66 IDC cross connect blocks within the equipment cabinet.

2. Cable Management

- a. Distribution rings shall be installed on the plywood backboard for voice cabling.
- b. Provide Quantities as Required.

3. Cross-Connect Cabling

1. Cross-connect cabling shall be NRTL-certified that it meets or exceeds the TIA/EIA UL category rating of the system installed.

2.9 FIBER OPTIC ETHERNET CABLING SYSTEMS

- A. All cabling shall meet or exceed ANSI/EIA-TIA-586-C.3, Optical Fiber Cabling Components Standard.

B. Manufacturers:

1. Provide products meeting the requirements of the Drawings and Specifications from one of the following Manufacturers:

Cable:	Corning, Superior Essex, Seicor, Berk-Tek
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NOTE: All cabling shall be Plenum-Rated.
Cabling installed in underground conduits shall be OSP gel-filled or OFNR Indoor/Outdoor Rated cables.

Connectors and Couplers:	SC connectors shall be by the cable manufacture
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Innerduct:	Carion, George-Ingraham, Pyramid Industries
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Patch Panels:	Shall be by the fiber optic cable manufacturer
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Patch Cables:	Shall be provided by fiber optic cable manufacturer
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Cable Management:	Shall be provided by fiber optic patch panel manufacturer.
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C. Fiber Innerduct: Provide from the MDF/MCER to each IDF/ICER.

1. Quantities Required: Innerduct runs do not have to be continuous throughout, breaks are expected at the pull boxes. Contractor is responsible for determination of actual lengths of innerduct required. Enough innerduct shall be provided and installed to extend from the fiber service loop in the MDF/MCER to the fiber service loop in each IDF/ICER. If the route passes through a pull box, the segments of innerduct shall extend 12 inches into the pull box.
2. Within equipment rooms innerduct shall be run directly into data racks in the MDF/MCER and IDF/ICER, innerduct shall face down within the data racks.
3. Innerduct shall be a minimum of 1.25 inches.
4. Conduit for innerduct shall be a minimum of 2 ½ inches.
5. Installation: Fiber innerduct shall be installed in accordance with manufacturer's instructions and industry standards. Care shall be taken to avoid kinking the innerduct or applying excessive tension during the installation process.

D. Fiber Optic Ethernet Backbone

1. Provide and terminate a 12-strand laser optimized OM4 10GbE Multimode fiber optic cable and a 6-strand laser optimized Single-mode fiber optic cable from the MDF/MCER to each IDF/ICER.
2. Provide and terminate a 6-strand laser optimized OM4 10GbE Multimode fiber optic cable from the MDF/MCER to each IDF/CER
3. Provide and terminate 6-strand laser optimized OM4 10GbE Multimode fiber optic cable from the concession Stand to the Stadium Press Box.
4. Provide and terminate a 2-strand laser optimized OM4 10GbE Multimode fiber optic cable from each site pole CCTV camera to the MDF/MCER in the high school.

E. Fiber Optic Cable

1. Multimode fiber optic cable:
 - a. Cable shall be certified to TIA/EIA 492CAAA, 492AAAB ANSI/TIA/EIA 568-C Series standard, and ISO/IEC 11801 fiber optic specifications, 50/125 micron, 850/1300 nm, laser optimized, graded video, dual window 6-pair (12 strands) tight buffer, Multimode distribution cable.
 - 1) Riser-rated Multimode cable - OFNR jacket, distribution cable for Riser applications.
 - 2) Plenum rated, Multimode cable - OFNP jacket, distribution cable for Plenum applications.
 - 3) The maximum attenuation measured at 23 degrees C. shall be 2.5 dB/km @ 850 nm and 0.7 dB/km @ 1300 nm. The minimum bandwidth shall be 500 MHz @ 850 nm and 500 MHz @ 1300 nm.
2. Single-mode fiber optic cable:
 - a. Cable shall be certified to TIA/EIA 492CAAA, IEC Publication 60793-2, Bellcore GR-20-CORE, and IITU Recommendation G.652 fiber optic specifications, 8.2 micron, 1310/1550 nm, graded video, dual window 3-pair (6-strand) tight buffer, single-mode distribution cable.
 - 1) Riser-rated single-mode cable - OFNR jacket, distribution cable for Riser applications.
 - 2) Plenum-rated, single-mode cable - OFNP jacket, distribution cable for Plenum applications.
 - 3) The maximum attenuation measured at 23 degrees C. shall be 0.05 dB/km @ 1310 nm and 0.50 dB/km @ 1550 nm.

3. Installation: Installation shall be conducted following guidelines established by the product manufacturer and industry standards.
 - a. Fiber Optic Cable: During installation of the optical fiber cable segments into the conduit system, special care shall be taken to avoid damage to the cable. While under pulling tension, the cable shall not be bent into a curve with a radius of less than twenty (20) times the cable diameter. Pulling tension shall not exceed manufacturer's recommended maximum tensile load. Contractor shall utilize a winch with tension control or a "break-away" link designed to break away at or below the recommended maximum tension.
 - b. The optical fiber cable shall be routed through the innerduct and onto the appropriate HC backboard. Routing on the backboard shall be straight and plumb. A minimum 10-foot service loop shall be provided at each terminal location.
4. Modular Connectors and Couplers
 - a. Fiber optic modular connectors/couplings shall be NRTL listed and TIA/EIA compliant, type "SC" terminations. Connectors and couplings shall be able to withstand a minimum of 2,000 mating cycles without any transmission degradation. Maximum optical loss budget shall not exceed .75 dB per termination and 1.5 dB per mated pair.
 - b. The connectors and couplings shall be compatible with the installed fiber optics: multi-mode 50/125 micron optics.
 - c. Fiber optic connectors shall be terminated by the following methods:
 - 1) Hot Melt
 - 2) Heat Cured Epoxy
 - 3) Ultra Violet Cured Epoxy
 - 4) Anaerobic
 - 5) Mechanical Splice with Index Matching Gel
 - d. Fiber optic connectors and couplers shall be provided by a single manufacturer.
5. Fiber Optic Patch Panels
 - a. Patch panels shall be capable of terminating all strands of the fiber optic cables installed in an IDF/ICER or the MDF/MCER.
 - b. Patch panels shall be rack-mounted 1.75 inch (44mm) high EIA nineteen inch (518mm) wide, rack mounted, drawer type with integral cable management, patch panels pre-loaded with duplex SC couplings.
6. Fiber Optic Patch Cables
 - a. Provide NRTL-certified TIA/EIA 492AAAA, TIA/EIA 568-C Series standard performance tested patch cables as required for a complete operational system. Patch cables shall be factory pre-connectorized, two-strand, tight buffer. Patch cables connectors shall be provided by the same manufacturers as the fiber optic connectors and couplings.
 - b. Fiber Optic patch cables shall be with "SC" to "LC" type connectors.
 - 1) Verify patch cable connectors with Owner prior to ordering.
 - c. One strand of the patch cable shall have a distinguishing mark throughout its entire length to simplify the distinction between Transmitting (Tx) and Receiving (Rx) at the patching area. Color coded factory marked (Tx-Rx) connectors are preferred.
7. Fiber Optic Cable Management

- a. Each equipment rack shall have horizontal and vertical cable management panels and brackets.
- b. Horizontal cable management shall be EIA 19-inch (482mm) rack mounted 1.75 inch (44mm) high drawer panel with integral cable management, and shall be provided for each fiber optic patch panel. This cable management drawer panel is for the fiber optic patch cables and is separate from the fiber optic patch panel drawer.

2.10 AUDIOVISUAL OUTLETS AND PATCH CABLING SYSTEM

A. Faceplate: C2G, Liberty, RCI

B. HDMI: High Speed Active, Directional HDMI Cable with Ethernet certified for support HDR, 4K, 3D, and Audio Return Channel

Cable: C2G RapidRun, Extron, Liberty

Jack Modules: C2G RapidRun, Extron, Liberty

Couplers: C2G RapidRun, Extron, Liberty

Line Cords and Patch Cables: Covid, Extron, C2G RapidRun, Liberty

1. HDMI cable shall be equivalent to C2G Cable - In-Wall CL3-Rated

Maximum Video Settings:	50' = 2160P@30Hz (4K -10G) 75' = 1080P@60Hz (12 bit) 100' = 1080P@60Hz (8 bit)
Connectors:	HDMI, 19Pin, Male, T-Grip, Overall AU Plating
Connector Hood:	Over-Mold, Black
Cable Jacket	PVC, Dark Blue Cable
Conductors	24 AWG*5P (STP)+4C
Overall Shield:	Copper Foil with Adhesive Backing
Outer Diameter:	.041"
Minimum Bend Radius:	.4.1"
Maximum Tensile:	15 kgf
Operating/Storage Temperature:	.-10°C ~ + 75°C
Operating Humidity:	50% ~ 75%
Number of Connector Mating Cycles:	3000
Compliances:	RoHS, Type CMP

2. HDMI Cables shall be rated for length of HDMI cable installed

3. HDMI cable lengths shall be field measured prior to installation. Cable lengths requiring more than 24 inches of cable to be coiled above ceiling is prohibited.

C. USB Active 2.0 USB Cable - A-Male to B-Male

Cable: C2G RapidRun, Extron, Liberty

Jack Modules: C2G RapidRun, Covid, Extron, Liberty

Couplers: C2G RapidRun, Extron, Liberty

Line Cords and Patch Cables: C2G RapidRun, Extron, Liberty

1. USB cable shall be equivalent to C2G Cable - In-Wall CL3-Rated

Connectors:	USB A - Male to USB B - Male
Number of Repeaters	25ft. & 35ft. = 1 50ft. & 75ft. = 2
Power Consumption.	52mA
Maximum Inrush Current	500mA
Connector Hood:	Over-Mold, Dark Blue
Cable Jacket	PVC, Dark Blue
Cable Conductors	24 AWG*1P+22 AWG*2C
Outer Diameter:	0.24"
Minimum Bend Radius:.	2.4"
Maximum Tensile: .	10 kgf
Operating/Storage Temperature:	-10°C ~ + 75°C
Operating Humidity: .	50% ~ 75%
Number of Connector Mating Cycles:	1500
Compliances:	RoHS, Type CMP

2. USB Cables shall be rated for length of HDMI cable installed
3. USB cable lengths shall be field measured prior to installation. Cable lengths requiring more than 24 inches of cable to be coiled above ceiling is prohibited

D. Audio

1. Flexible shielded audio cable with 3.5mm mini stereo connectors
2. Cables shall be terminated with gold plated 3.5mm female connectors at each end.

Cable:	C2G, Extron, Liberty
Jack Modules:	C2G, Extron, C2Gn, Liberty
Couplers:	C2G, Extron, C2G, Liberty
Line Cords and Patch Cables:	C2G, Extron, C2G, Liberty

3. Audio cable lengths shall be field measured prior to installation. Cable lengths requiring more than 24 inches of cable to be coiled above ceiling is prohibited.

E. VGA

Cable:	L-COM, C2G RapidRun, Extron
Jack Modules:	L-COM, C2G RapidRun, Extron
Couplers:	L-COM, C2G RapidRun, Extron
Line Cords and Patch Cables:	L-COM, C2G RapidRun, Extron

1. VGA cable shall be equivalent to L-COM number CTB3VGAMM-xxT.
 - a. The VGA cable shall have three (3) 75 ohm coaxial lines.

Conductor:	32 AWG Tinned Wire Stranded
Insulator:	Foam PE
Shield 1:	Spiral tinned Copper Wire
Conductor Resistance:	588 ohms/km Max at 20 Deg C
Dielectric Test:	500 VAC 1 min
Impedance:	75 ±10 ohms

- b. The VGA cable shall have nine (9) 30 AWG copper conductors.
 Conductor: 30 AWG 7-strand Tinned Copper Wire
 Insulator: Polypropylene
 Conductor Resistance: 376 ohms/km Max at 20 Deg C
 Dielectric Test: 500 VAC 1 min
- c. The VGA cable shall have an outer aluminized Mylar shield, and tinned copper braid and drain wire.
- d. The VGA cable shall have two (2) 15-pin molded housing connectors (P1 and P2), and two (2) 16-pin low profile, .079 in. (2mm) pitch disconnect connectors (P3-male, J1- Female).
- e. The VGA connectors shall be cabled as follows and shall interface to the applicable workstation, video source, Television, or Projector.

VGA CONNECTOR CABLING PIN ASSIGNMENTS

P1	P3	J1	P2	FUNCTION
1	1	1	1	RED SIGNAL
2	2	2	2	GREEN SIGNAL
3	3	3	3	BLUE SIGNAL
4	4	4	4	ID BIT 2
5	5	5	5	GROUND
6	6	6	6	RED SHIELD
7	7	7	7	GREEN SHIELD
8	8	8	8	BLUE SHIELD
9	9	9	9	DDC +5V
10	10	10	10	SYNC RETURN
11	11	11	11	ID BIT 0
12	12	12	12	ID BIT 1
13	13	13	13	HORZ. SYNC
14	14	14	14	VERT. SYNC
15	15	15	15	ID BIT 3, CLOCK
SHELL	16	16	16	CABLE SHIELD

- 2. VGA cable lengths shall be field measured prior to installation. Cable lengths requiring more than 24 inches of cable to be coiled above ceiling is prohibited.
- 3. Coupler shall be equivalent to L-COM part number DGBH15MF.
- 4. Patch cables and line cords.

- a. Patch cables and line cords shall be HD15 male to HD 15 female, equivalent to L-COM number CTL3VGAMF-xxB.

2.11 PATCH PANEL, PATCH CABLE, AND LINE (STATION) CORD QUANTITIES

- A. Patch Panels: Provide sufficient quantities of Category 6e patch panels in each wire center (MDF/MCER, IDF/ICER) to allow for twenty percent (20%) growth.

B. Patch Cabled: Provide Patch Cables as follows

1. Provide one (1) Category 6e UTP patch cable plus 15% spare for each horizontal Category 6e UTP cable terminated within the patch panels.
 - a. 60% of patch cables shall be 7 feet.
 - b. 40% of patch cables shall be 5 feet.
2. Confirm colors, lengths and quantities of cables with the Owner prior to ordering.

C. Fiber Patch Cords: Provide Fiber Patch Cables as follows

1. Confirm type, lengths and quantities with the Owner of all fiber patch cables to provide prior to ordering.
2. Field measure to verify all patch cable lengths necessary prior to ordering.
3. Provide two (2) 6-foot minimum (2 meter) Multimode duplex SC to LC fiber optic patch cables plus 15% spare for each Multimode fiber optic pair in the project.
4. Provide two (2) 6-foot minimum (2 meter) Single duplex SC to LC, fiber optic patch cables plus 15% spare for each Single mode fiber optic pair in the project.

D. Line (Station) Cords: Provide Line (Station) Cords as follow. Field measure and confirm with the Owner to verify all line cords lengths necessary prior to ordering.

1. UTP Line Cords:

- a. Provide one (1) 10-foot minimum (3 meter) Category 6e line cord cable plus 15% spare for each Category 6e data connector installed in all Work Area Outlets.
- b. Confirm colors, lengths, and quantities of cables with the Owner prior to ordering.

2. HDMI Line Cords:

- a. Provide one (1) 10-foot minimum (3 meter) high speed active HDMI line cord cable plus 15% spare for each HDMI connector installed in all Low (18" A.F.F.) Work Area Outlets.
- b. Provide one (1) 6-foot minimum (2m) high speed active HDMI line cord cable plus 15% spare for each HDMI connector installed in Work Area Outlets.

3. VGA Line Cords:

- a. Provide one (1) 10-foot minimum (3 meter) VGA cord with male connectors plus 15% spare for each VGA connector installed in all Low (18" A.F.F.) Work Area Outlets.
- b. Provide one (1) 6-foot minimum (2m) VGA cord with male connectors plus 15% spare for each VGA connector installed in all High Work Area Outlets.

4. Audio Line Cords:

- a. Provide one (1) 10-foot minimum (3 meter) 3.5mm Audio line cord with male 3.5mm connectors plus 15% spare for each Audio 3.5mm female connector installed in all Low (18" A.F.F.) Work Area Outlets.
- b. Provide one (1) 6-foot minimum (2 m) Audio line cord with male 3.5mm connectors plus 15% spare for each Audio 3.5mm female connector installed in all High Work Area Outlets.

2.12 SURGE AND LIGHTNING PROTECTION

- A. Provide Surge and Lightning Protection for all exterior aerial copper cables.

- B. Provide Surge and Lightning Protection for all copper cables run underground.
- C. All surge and lightning protection devices shall be connected to a low inductive path to earth ground.
- D. All exterior mounted surge and lightning protection devices shall include weatherproof housings.
- E. Provide lightning protection devices with the proper voltage rating for the applicable cable applications, per manufacturer's recommendations.
- F. UTP Cables.
 - 1. DEMARC TO MDF/MCER - All UTP cables run from the DEMARC Cross-Connect to the MDF/MCER Main Distribution Cross-Connect through underground conduits shall be OSP rated cables with each conductor protected on both ends by lightning/surge protectors. Lightning/surge protectors shall be equivalent to Citel #E280 series, see the following additional information for the application.
 - 2. IDF/ICERS TO MDF/MCER - ALL UTP CABLES RUN FROM THE IDF/ICER'S CROSS-CONNECT TO THE MDF/MCER MAIN DISTRIBUTION CROSS-CONNECT THROUGH UNDERGROUND CONDUITS SHALL BE OSP RATED CABLES WITH EACH CONDUCTOR PROTECTED ON BOTH ENDS BY LIGHTNING/SURGE PROTECTORS. LIGHTNING/SURGE PROTECTORS SHALL BE EQUIVALENT CITEL #E280 SERIES, SEE THE FOLLOWING ADDITIONAL INFORMATION FOR THE APPLICATION.
 - 3. BETWEEN BUILDINGS, BETWEEN THE NEW MDF/MCER AND THE EXISTING MDF/MCER CLOSET SHALL BE OSP RATED CABLES WITH EACH CABLE PROTECTED ON BOTH ENDS BY LIGHTNING/surge protectors. Lightning/surge protectors shall be equivalent to Citel #E280 series, see the following additional information for the application.
 - a. Basis of Design
 - 1) CITEL, 1515 N W 167th Street - Suite 5-223, Miami, FL 33169, TEL: 800-248-3548 / 305-621-0022.
 - b. Surge Protection Device.
 - 1) Base: Citel #FP10-110, or equal
 - a) Cable Capacity: 10 pairs
 - b) Connector type: 110.
 - c) Module Capacity: 4
 - c. Modules used for the applicable applications.
 - 1) Citel #E280T, or equal for analog voice applications.
 - 2) Citel #E280-48DBC, or equal for T1/ISDN voice applications.
 - 3) Citel #E280-6BC, or equal for Fast RS 485 applications.
 - 4) Citel #E280-6V, or equal for RS 422, RS 423, RS 485 applications.
 - 5) Citel #E280-24V, or equal for RS 232 and 4-20mA Loop applications.
- G. Other Non-Fiber Cables (i.e. 25V Speaker, 24V Clock, 24V Intrusion Alarm, 24V Access Control)
 - 1. DEMARC TO MDF/MCER - All cables run from the DEMARC to MDF/MCER through underground conduits shall be OSP rated cables with each conductor protected on both ends

- by lightning/surge protectors. Lightning/surge protectors shall be equivalent Citel #E280 series, see the following additional information for the application.
2. MDF/MCER TO IDF/ICER - All cables run from the MDF/MCER to IDF/ICER Closets through underground conduits shall be OSP rated cables with each conductor protected on both ends by lightning/surge protectors. Lightning/surge protectors shall be equivalent Citel #E280 series, see the following additional information for the application.
 3. MDF/MCER, IDF/ICER, OTHER INTERIOR LOCATIONS, TO EXTERIOR LOCATIONS - All cables run from the MDF/MCER Closet and IDF/ICER Closets to Exterior Locations through underground conduits shall be OSP rated cables with each conductor protected on both ends by lightning/surge protectors. Lightning/surge protectors shall be equivalent Citel #E280 series, see the following additional information for the application.

a. Basis of Design

- 1) CITEL, 1515 N W 167th Street - Suite 5-223, Miami, FL 33169, TEL: 800-248-3548 / 305-621-0022.

b. Surge Protection Device.

- 1) Base: Citel #FP10-110, or equal
 - a) Cable Capacity: 10 pairs
 - b) Connector type: 110.
 - c) Module Capacity: 4
- 2) Citel #E280-24V Module, or equal used for the applicable applications.
 - a) 25V Public Address.
 - b) 24V Clock Applications.
 - c) 24V Intrusion Alarm.
 - d) 24V Access Control
 - e) Other 24V applications.

PART 3 - EXECUTION

3.1 GENERAL

- A. The requirements of Part One and Part Two of the Specifications also apply to the execution of the work.
- B. Verify the exact location prior to bid of all items that may be indicated and determine exact location of all electrical items that are not indicated on the Drawings.
- C. Include the cost of all work, including sub-letting of any work that may be required to complete the work indicated, in order to avoid work stoppages and jurisdictional disputes. The work to be sublet shall conform to precedent agreements and decisions of record. Jurisdictional assignment shall be a responsibility under this Section's contractual obligation.
- D. Do not install equipment and materials that have not been reviewed by the Architect. Equipment and materials that are installed without the Architect's review, or without complying with comments issued with the review, shall be removed from the project when so instructed by the Architect. No payment will be made for unapproved equipment or materials, or removal if they are ordered removed. The Contractor shall be responsible for any ancillary costs incurred because of its removal, and for the installation of the correct equipment and materials.
- E. At the start of construction, consult with the Construction Manager and all Trades, and determine and verify the electrical characteristics of all equipment that is supplied under the Contract.
- F. Obtain detailed information on installation requirements from the manufacturers of all equipment to be furnished, installed, or provided. At the start of construction, check all Contract Documents, including all Drawings, and all Sections of the specifications, for equipment requiring electrical connections and service, and verify electrical characteristics of equipment prior to roughing.
- G. Request the Construction Manager to provide, as soon as possible after approval, two copies of approved submittals of equipment that requires electric service, electric connections, or electric controls. Review these submittals for characteristics and return the submittals to the Construction Manager, noting any non-agreement within two weeks of receipt.
- H. Equipment and systems shall not be installed without first coordinating the location and installation of equipment and systems with the Construction Manager and all other Trades.
- I. Any and all material installed, or work performed, in violation of above requirements shall be re-adjusted and corrected by the Installer without charge.
- J. Refer to all Drawings associated with the project, prior to the installation or roughing-in of the electrical outlets, conduit, and equipment, to determine the exact location of all outlets.
- K. After installation, equipment shall be protected to prevent damage during the construction period. Openings in conduits and boxes shall be closed to prevent the entrance of foreign materials.
- L. Home runs indicated are not to be combined or reduced without written consent from the Architect.
- M. All connections to equipment shall be made as required, and in accordance with the approved submittal and setting drawings.
- N. Delivery, Storage, and Handling:

1. Deliver, store, protect, and handle products in accordance with recommended practices listed in Manufacturer's Installation and Maintenance Manuals.
2. Deliver equipment in individual shipping splits for ease of handling; mount on shipping skids and wrap for protection.
3. Inspect and report concealed damage to carrier within specified time.
4. Store in a clean, dry space. Maintain factory protection or cover with heavy canvas or plastic to keep out dirt, water, construction debris, and traffic. Provide heat enclosures to prevent condensation. Meet the requirements and recommendations of NFPA 70B and the Manufacturer. Location shall be protected to prevent moisture from entering enclosures and material.
5. Handle products in accordance with NEMA and the Manufacturer's recommendations and instructions to avoid damaging equipment, installed devices, and finish.
6. The equipment shall be kept upright at all times. When equipment has to be tilted for ease of passage through restricted areas during transportation, the Manufacturer shall be required to brace the equipment suitably to insure that the tilting does not impair the functional integrity of the equipment.

O. Site Observation:

1. Site observation visits will be performed randomly during the project by the Architect. Reports will be generated noting observations. Deficiencies noted on the site visit reports shall be corrected. All work shall comply with the Contract Documents, applicable Codes, regulations, and local Authorities, whether or not a particular deficiency has been noted in a site visit report.
2. Be responsible to notify the Architect ten working days prior to closing-in work behind walls, raised access floors, and ceilings so that installed work can be observed prior to being concealed.
3. Work concealed prior to observation and correction of deficiencies shall be made accessible for review at the discretion of the Architect. The Contractor shall bear all costs for reviewing work.
4. Areas shall stay accessible until deficiencies are corrected and accepted. Notify the Architect when all deficiencies are corrected. Return reports with items indicated as corrected prior to re-observation by the Architect.

P. Change Orders, Modifications, Revisions, and Directives:

1. When change orders, modifications, revisions, or Architect's Directives are issued or authorized, provide the required additional material, equipment, personnel, and workers to prevent delays in the work, and to complete the work within the time limit of the Contract, unless a specific time extension is requested with the change and accepted. Include costs for expediting deliveries, where required.
2. Requests for additional compensation shall be submitted broken down and associated by item, task and Drawing, or sketch number, with material and labor costs, so that quantities can be easily verified.
3. Requests shall be properly and adequately identified so the scope of work can be clearly determined. Indicate who originated change in work.
4. Cost breakdowns shall be submitted complete with backup for material and labor units and costs. Backup shall consist of actual vendor invoices or quotes, or from well-known national organizations such as R.S. Means Company, National Trade Service, Union labor rates or approved equal. Installing firm's in-house standard database for labor units may be used if consistent with the national organizations.
5. Submit on all credits, broken down as requested for adds. Credits shall be separately identified and accounted for. Do not indicate as net changes with adds.
6. Unit costs for labor and material shall be equal for adds, deletes and credits.

3.2 WORK

- A. Loose materials shall not be stored on-site. A "gang box" is acceptable to be placed in a location agreeable to the Owner and the Construction Manager. The Contractor is responsible for all equipment and materials and for their delivery until the system is deemed complete and accepted by the Owner.
- B. A trailer may be used for the storage of materials to be located on the Owner's property at a location designated by the Owner and the Construction Manager. Such on-site storage shall be kept locked by the Installer. Security for the trailer and its contents shall be strictly the responsibility of the Installer.
- C. Protect existing spaces where work is being performed to protect it from damage and from the accumulation of dirt.
- D. Any ceilings, walls, floors, furniture, equipment, and furnishings damaged by the work of the Contract shall be replaced, or at the Owner's option, repaired with similar materials, workmanship, and quality.
- E. Work includes field survey of existing conditions, systems, equipment, and tracing of existing circuits in order to determine scope of work.
- F. Maintain the existing building in operation at all times during the entire construction period. If it is necessary to have a system shutdown, a written request for approval shall be submitted in advance, stating the estimated shutdown time. Work shall be planned to minimize shutdown. Shutdowns shall be at the convenience of the Owner and, if necessary, on premium time.
- G. Clean and touch up all equipment, materials, and work sites at the completion of work in each area.
- H. Certain portions of the work area may be occupied during construction. Determine which areas and schedule work accordingly, and include necessary premium time.
- I. Make sure necessary provisions are made to provide continuous service of all existing systems throughout all occupied areas.
- J. Existing System Operation:
 - 1. It is imperative that completely operable and operating computer systems be maintained in all areas of the building where such operation is provided.
 - 2. Temporary and short-interval interruptions of the capability of a single existing system zone, in any area of the building, to operate to complete installation of the building network according to the building construction phases, may be tolerated with the express written permission of the Owner. This permission will only be considered if a written request for such an interruption is made before the actual need therefore.

3.3 EQUIPMENT RACKS, CABINETS, AND BRACKETS

- A. Securely mount freestanding and wall-mounted equipment racks and cabinets to the building structure. Equipment racks shall be secured to the building structure at the top and bottom of the rack. 3/8" lag screws and expansion anchors shall be used. Proper quantity of supports shall be utilized. Drywall screws and other types of supports not specifically approved to support equipment are specifically prohibited. Submit mounting supports for approval before installation.
- B. Position racks, cabinets, and wall-mounted relay brackets in order to have minimum three-foot clearance for easy access. Equipment racks, cabinets, and relay brackets mounted on or against

walls shall have three-foot clearance in front of deepest component. Free-standing equipment racks and cabinets shall have three-foot clearance in front and rear of deepest components. Provide three-foot clearance between free-standing equipment racks or cabinets and any other obstruction to allow access from front to rear of rack or cabinet for maintenance.

- C. The Electrical Contractor shall provide ladder rack over each rack and cabinet as required to facilitate a neat and orderly installation of cables, and to secure the top of the racks to the structure. Cables shall drop straight down to equipment racks. Ladder racks shall be secured to the structure at both ends, and connected together as required for a complete, contiguous installation. Utilize proper supports to support the ladder rack to the building structure, as well as the equipment rack and cabinet. Submit mounting supports for approval before installation.
- D. Install terminating components such as patch panels (UTP, Fiber optic) and cable management into the racks, cabinets and wall-mounted relay brackets.
- E. Patch Panels: Mount patch panels onto the rack(s) in top-to-bottom fashion with the first patch panel mounted at the top of the rack. Uniquely label each patch panel according to the numbering convention outlined in the Labeling section. Each port shall also have color-coded identifiers. Refer to details on the Drawings.
- F. Cable Management: All cables shall enter the wiring closet to within the equipment racks and/or brackets. Secure the bundle(s) to the rack strain relief and wire management behind the patch panels, and cross-connect block panels. Install horizontal and side-mounted vertical cable management panels and brackets for routing and management of patch cables. Maintain TIA/EIA and BICSI standards on bundling, supporting, and bend radii.
- G. Once the cabling system has been installed and terminated, install all active components and surge-protected power strips into the racks, cabinets and wall-mounted relay brackets.
- H. Surge-Protected Outlet Strips: Mount UPS and surge-protected outlet strips per Manufacturer's directions. Refer to details on the Drawings for mounting location.

3.4 WORK AREA OUTLETS

- A. All Work Area Outlet locations shall be as indicated on the Electrical and Technology Series Drawings. Uniquely label each Work Area Outlet and jack within the outlet according to the numbering convention outlined in the Labeling section.
- B. Work Area Outlets installed in casework shall have their cables installed within the conduit or raceway provided.
- C. Work area outlets installed in powered furniture partitions shall have their cables installed within the integral furniture raceway.
- D. Install jack and connector modules as indicated in the details on the Drawings.
- E. Work Area Outlets shall be seated properly, and shall be installed level on walls, and parallel to building elements as required.

3.5 TERMINATIONS

- A. All copper or fiber conductors of every cable shall be completely terminated at both ends.
- B. Remove all abandoned cabling and devices.

3.6 CABLE PATHWAYS

- A. Install cables in pathways provided by the Electrical Contractor or required under execution part of the Contract.
- B. Provide all equipment and cabling for a completely installed operating system. In general, pathways, outlet boxes and grounding are provided by the Electrical Contractor. However, it is the responsibility of the Contractor under this Section to coordinate with the drawings and specifications for the Electrical Specifications, and to provide all pathways and outlet boxes required, but not provided by the Electrical Contractor.
- C. All pathways provided under this Section shall comply with fill capacities as per Code, TIA/EIA 569A and BICSI.
- D. Cable-bending radius shall not be less than minimum required by TIA/EIA, BICSI, and manufacturer.
- E. Cabling installed concealed shall be supported from the building structure (e.g. cable trays, J-Hooks, and snake tray).
- F. The Contractor shall be responsible for testing and verification that the entire building structure is free from EMI/RFI interference factors prior to installation of unshielded twisted pair station cabling.
- G. Voice and data cables shall not be bundled with nor run adjacent and parallel to other system cabling and wiring. Telecommunications cabling shall be routed separately and be installed no closer than 12 inches (305mm) to electrical or other building system cabling and wiring. When cables are required to cross power or other building system wiring, they shall only do so perpendicular to the wiring. Telecommunications cabling and power and other building system wiring shall only cross each other the minimal number of times as required due to building design limitations. Maximum number of cables per bundle shall be thirty (30).
- H. Similarly, telecommunications cabling shall be routed away from large motors, generators, induction heaters, arc welders, x-ray equipment, and radio frequency, microwave or radar sources.
 - 1. (9 ft.) from transformers
 - 2. (6 ft.) from motors
 - 3. (3 ft.) from conduit and cables used for electrical power distribution
 - 4. (2 ft.) from any power line over 5 kVA
 - 5. (5 in) from fluorescent lighting fixture. Pathways should cross perpendicular to fluorescent lighting fixture and electrical power cables or conduits
- I. Clearances: Clearances between cabling and other building systems, shall be maintained throughout the building.
- J. All cables shall be installed in a neat and workman-like manner. Cables shall be installed parallel and perpendicular to building elements.
- K. Provide expansion fittings and adequate cable slack at all building expansion joints.
- L. Contractors shall not run any cabling or pathways through elevator shafts, elevator machine room, stair tower enclosures unless these cabling or pathway systems serve the space.

3.7 SEALING OF PENETRATIONS AND OPENINGS

- A. Environmental Seals

1. Provide seals on raceways exposed to widely different temperatures, as in refrigerated or cold storage areas. Install seal to prevent circulation of air from warmer to colder sections through the raceway.
2. Provide seals under device plates for outlets on walls between conditioned and non-conditioned spaces.
3. Provide outlet plate gasket seals at all work area outlets on interior and exterior walls.

B. Smoke and Fire-Stopping Seals

1. Provide a seal around raceways or cables penetrating full height walls (slab to slab), floors or ventilation, or air-handling ducts, so that the spread of fire or products of combustion shall not be substantially increased.
2. Penetrations through fire-resistant-rated walls, partitions, floors or ceilings shall be fire-stopped, using approved methods and NRTL-listed products to maintain the fire-resistance rating.
3. Installation restrictions of the listing agencies shall be strictly adhered to (e.g. 24 inch (610 mm) minimum horizontal separation between boxes on opposite sides of the wall, maximum square inch opening in wall).
4. Fire-stopping in sleeves, or in areas having small openings that may require the addition or modification of installed cables or raceways, shall be a soft, pliable, non-hardening fire-stop putty. Putty shall be water-resistant and intumescent.
5. Fire-stopping in locations not likely to require frequent modification shall be a NRTL-listed putty or caulk to meet the required fire-resistance rating.
6. Box penetrations into a fire-rated wall or shaft shall have a fire-stopping pad installed on the back of the box.
7. Fire-stopping of cable trays, ladder racks, and snake trays through walls shall be with NRTL-listed bags to meet the required fire-resistive rating. Fire-stopping of cable trays, ladders, and snake trays through walls will not allow products of combustion to pass through the protected opening. The NRTL-listed bags shall be installed inside, and on both sides of, the opening as required to meet the required fire-resistive rating of the wall.
8. Fire-stopping materials shall be NRTL-listed to UL 1479 (ASTM E814). Installation methods shall conform to a UL fire-stopping system. Submit specifications and installation drawings for the type of material to be used. Fire-stopping materials shall be as manufactured by 3M, International Protective Coatings Corp., Specified Technologies, Inc., Carborundum Company, Raychem, Nelson Fire Stop, or approved equal.

3.8 SEISMIC SUPPORTS, SUPPLEMENTARY STEEL AND CHANNELS

- A. Provide all supports, supplementary steel and channels required for the proper Seismic installation, mounting, and support of all work installed under this Section.
- B. All supports, supplementary steel and channels shall be furnished, installed, and secured with all fittings, support rods, and appurtenances required for a complete support or mounting system.
- C. Supplementary steel and channels shall be firmly connected to the building construction in a manner approved by the Architect prior to the installation of same. Submit to the Architect, via the Construction Manager, the locations proposed for using supplementary steel and channels for the support of equipment, fixtures, and raceways. The submittal shall indicate the mounting methods, size, and details of the supports, channels and steel. Submittal shall also indicate the weight that the supports, channels, and supplementary steel are to carry.
- D. The type and size of the supporting channels and supplementary steel shall be of sufficient strength and size for seismic restraint and shall allow only a minimum deflection in conformance with the channel and supplementary steel manufacturer's requirements for loading.

- E. All supplementary steel and channels shall be installed in a neat and workmanlike manner, parallel to the walls, floor, and ceiling construction. All turns shall be made with 90-degree and 45-degree fittings, as required to suit the construction and installation conditions.
- F. All supplementary steel, channels, supports, and fittings, shall be Underwriters' Laboratories, Incorporated-approved, be galvanized steel, and be manufactured by Steel City, Unistrut, Power-Strut, T. J. Cope, Chalfant, or approved equal.
- G. Provide supports to meet the required Seismic rating, as indicated under "Part One" of this Specification.
- H. Provide beam clamps with set screws (C-clamp type).
- I. Work under this Section shall be held in place by Seismic-rated methods.
- J. Supporting from the roof decking will not be acceptable.
- K. Provide expansion anchors on masonry units or brick work. Power-actuated supports will not be accepted.
- L. Provide stainless steel or corrosion-resistant supports in corrosive areas, or in wet or damp areas.
- M. Support work from the building structure, independent of suspended ceilings, roof deck, or other trades work. Where ductwork, pipes, pipe racks, type of building construction materials, or structural framing members provide obstruction or difficult support means, hanger rods shall be used in association with horizontal sections of steel support channels, in an approved manner.
- N. All work shall be installed in a rigid and satisfactory manner, and shall be supported by bar hangers in frame construction, or shall be fastened directly with wood screws on wood, bolts with expansion shields on concrete, or brick toggle bolts on hollow masonry units, and machine screws or welded threaded studs on metal. Threaded studs of the proper type and holding capacity, driven in by a power charge, and provided with lock washers and nuts, are acceptable for mounting of equipment on solid concrete walls or slabs.
- O. Obtain written permission from the Construction Manager to allow use of power-activated charges. Use only properly trained and licensed operators.
- P. Do not use power charge-driven supports for any work that is to be hung from a horizontal surface without written permission from the Architect.
- Q. Preset inserts of the proper type and holding capacity shall be used in overhead slab construction wherever possible.
- R. Provide lateral supports for work to prevent excessive movement during a seismic event, using rods, braces, or galvanized or stainless steel cables.
- S. Pendants, supports, or hanging rods longer than 12 inches (300mm) shall be laterally braced.
- T. Where installed in damp, wet areas, and areas requiring wash-down, all surface-mounted panels, boxes, junction boxes, and conduits shall be supported by spacers to provide clearance between wall and equipment.

3.9 CABLE SUPPORTS

- A. Provide strain-relief hardware for backbone cables at each floor level as they pass from one floor to the next.
- B. Provide hook-and-loop (Velcro) cable wraps at all panels, equipment racks, and cabinets. Cable ties are specifically prohibited.
- C. Cable ties for horizontal cables shall be secured with minimum required compression in order to secure the cables properly without impeding the signal-transmission rating (geometry) of the cable. Hook-and-loop (Velcro) cable wraps may be used in lieu of cable-ties. Cable-ties are specifically prohibited for fiber optic cables.
- D. When pathways are not provided or specified, provide J-Hook supports from the building structure, as required for cable runs to the cable drop location. Maximum distance between supports shall be five feet, depending on the structural elements of the building. Provide additional supports as required to maintain required bending-radius of cables. Cables installed exposed or in areas subject to abuse (below 10 feet (3m) above finished floor), or in accessible areas, shall be installed in conduit.
- E. All cables shall be supported directly from building structure. Under no circumstance shall cable be installed using cross-bracing, plumbing/sprinkler pipes, ceiling systems, or any other system that is not a specifically approved method to independently support cables. Cables shall not be allowed to rest on ceiling tiles, duct work, piping, joists, or other building system items. Supports shall be provided as required in order for cables to avoid contact with any other building system. Bundle Telecommunications cables in groups by Room.
- F. Total number of cables per J-Hooks shall not exceed 50% of manufacturer's recommendation.

3.10 CABLE PROTECTION

- A. Provide bushings in all metal studs and the like where cables will pass through. Bushings shall be of two-piece construction with one piece inserted through the opening and the second piece locking it into place. Single-piece bushings with locking tabs or friction fit are specifically prohibited.
- B. Cables to be installed in existing, enclosed, open bays or furred spaces where conduit stubs are not provided, shall be protected from chafing or from any damage. The Installer shall verify that the warranty shall not be violated before installing any cabling in these locations.
- C. Provide cutting, coring, sleeves, and bushings, and seal as required at all penetrations.
- D. Fiber optic backbone cables shall be installed in inner duct.
- E. Cables damaged during installation shall not be repaired. They shall be completely replaced with new cable.

3.11 GROUNDING

- A. General:
 - 1. The Telecommunications systems, consisting of cable tray, ladder rack, snake tray, equipment cabinets, racks and non-current carrying metallic parts, shall be grounded according to the Electrical Code.
 - 2. In general, the grounding shall be as specified, as indicated on the Drawings, and as required by the Electrical Code and Local Authorities.

B. Methods:

1. Provide equipment grounding connections for integrated sound, voice, and video systems as indicated. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.
2. Ground equipment, conductor, and cable shields to eliminate shock hazard and to minimize to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.
3. The installer shall provide all necessary transient protection on the AC power feed and on all station lines leaving or entering the building.
4. The installer shall note in his system drawings, the type and location of these protection devices as well as all wiring information.
5. The installer shall furnish and install a dedicated, isolated earth ground from the central equipment rack and bond to the incoming electrical service ground bus bar.

C. Telecommunications Grounding

1. Raceways, including wireways, conduits, cable trays, ladder rack, snake tray installed for low voltage or fiber optic cabling, shall be made electrically continuous for grounding purposes. Provide hollow, braided-copper jumpers between sections equal to Belden No. 8669 (60A Ampacity). Provide equal impedance conductor for aluminum raceway.
2. Bond raceways to the ground bus located in the equipment cabinet. Bond raceways in each room in which they terminate.

D. Telecommunications Equipment Bonding and Grounding

1. Provide grounding and bonding as required by TIA/EIA-607 standards, codes and the equipment manufacturers.
2. Make final grounding conductor connection to cabinet around bus.
3. Each individual piece of equipment shall have an individual grounding conductor to the ground bus within the cabinet.
4. All equipment shall have bonding jumpers between them (i.e. between cable tray, ladder rack, snake tray and equipment rack).
5. Equipment integral to an equipment rack (i.e. shelves, panels, and cable management) shall be considered bonded.
6. Equipment that is not integral to an equipment rack (i.e. shelf mounted electronic equipment, cable tray, ladder rack, and snake tray) requires individual bonding jumpers between the equipment and the rack.
7. Properly clean and prepare all surfaces for a complete bonding and grounding termination.
8. Install grounding bus in all equipment racks and cabinets.

3.12 INSTALLATION

- A. All cabling shall be installed in conduit where indicated on plans, or shall be installed open, using other methods approved by architect, such as J-Hooks, cable tray, ladder rack, and snake tray.

1. All wiring shall be new, per manufacturer's recommendations, in raceway, except within consoles, desks, and counters, and except in accessible ceiling spaces, and in gypsum board partitions, where cable wiring method may be used. Use UL-listed plenum cable in environmental air spaces, including plenum ceilings.

- B. All conduits, raceways, and innerduct shall have pull-strings remaining after cable is pulled.

- C. Control Circuit Wiring:

1. Install control circuits in accordance with NFPA 70 and as indicated. Provide number of conductors recommended by system manufacturer to provide control functions indicated or specified.
2. All housings are to be located as specified and shown on drawings.
3. Make installation in strict accordance with approved manufacturer's drawings and instructions.
4. The Installer shall provide necessary transient protection on the AC power feed, all station lines leaving or entering the building, and all central office trunks. All protection shall be as recommended by the equipment supplier and referenced to earth ground.

D. Weatherproofing:

1. Provide weatherproof enclosures for items to be mounted outdoors or exposed to weather.

3.13 UTP CABLING SYSTEMS

- A. The general topology shall be a "hierarchical star" configuration. All segments shall originate in NRTL-listed patch panels, located in the telecommunication equipment racks/cabinets, and shall end at the Work Area Outlet.
- B. Backbone cables shall be installed in EMT between the head end (MDF/MCER) and the telecommunications closets (IDF/ICER).
- C. Routing
 1. All cabling shall be installed in conduit where indicated on plans, or shall be installed open using "J" hooks or Snake Tray.
 2. Cables shall be routed, in large groups, down main cable pathways, until a direct path to the point of access to the work station outlet can be taken. At that point, cables shall be routed, above all building systems, to the outlet location, in accordance with standard installation practices as described herein.
 3. Multiple cables to individual rooms shall be pulled as in bundles and terminated at each end in sequential order so that labeling within a room location is in sequence.
 4. When not in conduit or tray, cables shall be supported to the deck and/or beams, every five feet throughout the length of their installed run. Hangers, clips, and other methods of grouping the cables and keeping them away from other systems installed in the building are to be provided and installed. Ensure that hangers and other methods of securing cable do not compress cable or damage insulation.
 5. Route Telecommunications data cable bundles separately and 12 inches (305mm) from other building systems wiring.
 6. Route cables minimum of 12 inches (305mm) away to avoid light ballasts, transformers, power wiring, and other electrical devices, so that there is no EMI or RFI interference with data transmission.
 7. Cables shall be attached to beams with minimal disruption of the fireproofing. Care should be taken to assure that fireproofing removal is not excessive. The Telecommunications Cabling Contractor shall be responsible for restoring the fireproofing to appropriate levels. Restoration will be verified by the Construction Manager.
 8. Cable routes shall be within 90-degree angles whenever possible. Cables shall not be installed randomly or diagonally through the building.
 9. Cables installed partially or fully within the communications room shall be routed through, and secured in, the cable tray or ladder rack. No cables are to be routed across the rooms at angles, nor are the cables to be run from one portion of the room or tray to another. Cables placed in the cable tray or ladder rack are to be laced frequently to keep them neatly bundled and to prevent them from shifting from one side of the tray to the other as they are routed in the tray.
 10. Station cables shall be routed to fixed-wall locations through EMT to back box. Secure and store four feet of slack cable above ceiling at cable entrance to EMT.

- D. All horizontal cables shall be terminated at their respective equipment racks/cabinets.
- E. All cables shall have both ends completely terminated at their respective patch panel and Work Area Outlet. Individual conductors shall be trimmed flush with IDC block. Cables indicated to be "spare" shall have one end terminated at their respective patch panel or cross-connect block and the other end shall be hermetically sealed with a polyolefin heat-shrinkable cap. Provide Raychem Co. or approved equivalent after testing. Tape shall not be approved.
- F. The total length of permanently installed cable for any complete segment shall not exceed 295 feet (90m). Do not splice or otherwise re-terminate any cable used. Terminate only at the patch panels, cross-connect blocks, and Work Area Outlets.
- G. Permanently label all cables six inches from the connector at each end, according to the numbering convention outlined in the section on labeling.
- H. Maximum pulling tension shall not exceed 25 lbs/ft. when installing cables.
- I. Modular Jacks
 - 1. Each Category 6e jack shall have a Category 6e cable home run back to its associated patch panel or cross-connect block.

3.14 FIBER OPTIC CABLING SYSTEMS

- A. Cabling
 - 1. The general topology shall be star configuration. All segments shall originate from NRTL-listed fiber optic patch panels, located in equipment rack/cabinet and be distributed to fiber optic patch panels in next equipment rack/cabinet.
 - 2. All 12 strands within the fiber optic backbone cable shall have both ends terminated in their respective patch panels. "Dark" fibers are not allowed.
 - 3. All fibers supplied in cable shall be usable fibers and meet required specifications. "Spare" unspecified fibers shall not be allowed.
 - 4. Multimode fiber optic cable:
 - a. Multimode fiber optic cable shall be furnished and installed from the main cross-connect to each equipment rack/cabinet.
 - 5. Pulling tension shall not exceed 25 lbs/ft when installing cables.
 - 6. Fiber Optic Cable Management
 - a. Hook-and-loop (Velcro) type cable wraps shall be secured with minimum required compression in order to secure cables properly. Cable ties are strictly prohibited.
 - b. Split-mesh, metal strain-relief's (Kellums) shall be provided to secure cables installed vertically.
 - c. Fiber Optic Patch Panels
 - 1) Provide silk screening on panel to distinctly identify transmit (Tx) and receive (Rx) at each port. Provide large, bold label, indicating information similar to "CAUTION - SEVERE EYE DAMAGE! DO NOT LOOK INTO FIBER OPTIC CONNECTOR WHILE ENERGIZED!", and mount signage to the fiber optic patch panel.
 - 2) Final connection of patch cables is provided under this Section.
 - d. Innerduct

- 1) All fiber optic cabling shall be installed in innerduct.
- 2) Provide 1 1/4 inch inner ducts with 200-pound-test pull line, above ceilings through the building.

3.15 PATCH PANELS, PATCH CORDS, AND LINE CORDS

- A. Deliver all patch cables and line cords thirty (30) days prior to Substantial Completion Date.
- B. Obtain delivery sheets signed by the Owner for all patch cable and line cord deliveries with signatures, quantities and type clearly identified. Indicate storage location on the delivery sheets for all patch cable and line cords.
- C. Submit all signed delivery sheets with Closeout Documentation.

3.16 LABELING

- A. Labeling procedure shall meet TIA/EIA-606 Series and BICSI standards and shall be pre-approved by the Architect. Hand-written and embossed-type labels are specifically prohibited.
- B. Permanently label, using pre-printed labels, all cables and terminations exactly as defined herein:
 1. Label each equipment rack and cabinet.
 2. Label patch panels and cross-connect blocks numerically, top-to-bottom
 3. Label each patch panel port with the wall outlet jack it is cabled to so that each patch panel port can be associated with its corresponding end node location.
 4. Label patch panel and cross-connect blocks ports numerically.
 5. Label the cable segments as indicated on Drawing Schedules. Each outlet will be designated by the incoming cable, and will be labeled accordingly.
 6. Label each equipment rack, panel, and cross-connect block uniquely.
 7. Refer to Administration section for specific labeling requirements.
- C. Use industry standard TIA/EIA and BICSI color codes, as specified herein, and maintain consistent color-coding throughout the building.

3.17 TELECOMMUNICATIONS IDENTIFICATION

- A. All equipment and cabling shall be properly identified by means of clear and concise labels. All identification shall meet or exceed the minimum requirements of TIA/EIA-606 Series and BICSI standards.
- B. Permanently label, using pre-printed labels, all cables and terminations. Handwritten or embossed type labels are specifically prohibited.
 1. Label all equipment racks, panels, and cross connect blocks uniquely.
 2. Label patch panels and cross-connect blocks numerically, top-to-bottom.
 3. Label cable segments by designated incoming cable.
- C. Labels
 1. Provide color-coded labels with CODED identifiers as follows:
 - a. Conduits and other pathways shall be labeled at all end points, including equipment rooms, telecommunications closets, pull boxes and the like. Provide adhesive labels on all conduits, with at least one label within each space that the conduits pass through. Labels

- shall be attached by means of the label adhesive and color-coded pressure-sensitive tape wrapped around conduit at least one and one-half times.
- b. Cables shall have double lapped adhesive labels at all end points including Work Area Outlets, telecommunication closets and equipment rooms. Cables shall also have factory imprinted manufacturer's name, part number, and the NRTL-certified UL TIA/EIA category rating designation at a minimum of two foot (610mm) intervals along the entire length of the cable.
 - c. Termination hardware shall have adhesive labels on both the front and rear (if accessible) of the hardware.
 - d. Insert Labels shall be provided in each Work Area Outlet patch panel termination hardware (top of jack), cross connect blocks (edge of block), and the like.
 - e. Outlet boxes, junction boxes, and the like shall have adhesive labels attached on the inside and located where visible from the outlet opening.
 - f. Grounding and bonding systems shall have engraved labels at each ground bar and backbone grounding cable as it passes through each room. Each bonding jumper shall have heat shrink labels at all end points.
2. Labels shall be constructed of approved material in order to meet the legibility, defacement, adhesion (adhesive labels only), and exposure requirements of UL 969. All labels shall be mounted horizontally in order to be read from left to right.
- a. Adhesive Labels shall be constructed of color-coded paper with a clear polyester over laminate, Brady USA, Inc. PermaShield, Raychem TMS, or approved equal. Adhesive material used shall be approved for material being attached to, typeface shall be medium density, Helvetica, 1/8 inch (3mm) high black characters unless indicated otherwise.
 - b. Heat-Shrink Labels shall be constructed of color-coded flame retardant, heat shrinkable polyolefin, Brady USA, Inc, Raychem TMS, or approved equal. Typeface shall be medium density, Helvetica 1/8 inch (3mm) high black characters unless indicated otherwise.
 - c. Insert Labels shall be constructed of color-coded paper inserted behind clear plastic label holder. Work Area Outlets shall have white color labels inserted behind a flush mounted (recessed) plastic window. Patch panels and cross-connect block may have continuous clear plastic insertion strip label holders with label strips. Label strips shall have distinct markings to indicate where one jack or cross-connect ends and the adjacent one starts. Typeface shall be medium density, Helvetica 1/8 inch (3mm) high black characters unless indicated otherwise.
 - d. Each Network Interface Outlet shall have each of its eight-position modular jacks provided with a color-coded, embossed modular ICON. The telephone jack icon shall be white and shall have either the word "VOICE" or a telephone logo. The data jack icon shall be blue and shall have either the word "DATA" or a computer logo. The Network Interface Outlet jack provided shall also be able to have additional ICON types such as, but not limited to, "LAN1 " or "LAN2" and the like available for use. Coordinate with the Owner through the architect, the specific icons required for this project.
 - e. Handwritten or embossed labels are not allowed.

3. Color Coding

- a. Provide hierarchical color-coded labels as follows:

1) Terminations Color Code:

TERMINATION TYPE	COLOR	PANTONE	COMMENTS
Demarcation point	Orange	150C	Central office terminations

TERMINATION TYPE	COLOR	PANTONE	COMMENTS
Network	Green	353C	Network or connections auxiliary circuit termination
Common equipment PBX, Host, LANS, Muxes	Purple	264C	Used for all major switching and data equipment terminations
First level backbone	White		MC-IC cable terminations
Second level backbone	Gray	422C	IC-TC cable terminations
Data horizontal	Blue	291C	Data System Horizontal cable terminations
Miscellaneous	Yellow	101C	TERMINATION TYPE
Telephone Horizontal	Red	184C	Telephone system horizontal cable termination

- b. Horizontal Cables Color Code: All horizontal and backbone connection hardware shall have color-coded labels.
- c. Cables shall be standard manufacturer's colors.
- d. All Category cables shall be different colors: Category 5, 5e, 5E and Category 6A cables.
- e. Voice cables shall be different color than data cables.
- f. Backbone Cables Color Code:
 - 1) Shall be standard manufacturer's colors. Category 3 backbone cables overall color shall be a different color than Category 5, 5e, 5E and 6 backbone cables overall color. UTP backbone cables shall have different colors than fiber optic backbone cables.
 - 2) 25 pair UTP backbone cables shall have their conductor pairs color-coded as follows:

PAIR COMBINATION	COLOR CODE
1 White/Blue	Blue/White
2 White/Orange	Orange/White
3 White/Green	Green/White
4 White/Brown	Brown/White
5 White/Slate	Slate/White
6 Red/Blue	Blue/Red
7 Red/Orange	Orange/Red
8 Red/Green	Green/Red
9 Red/Brown	Brown/Red
10 Red/Slate	Slate/Red

PAIR COMBINATION		COLOR CODE
11	Black/Blue	Blue/Black
12	Black/Orange	Orange/Black
13	Black/Green	Green/Black
14	Black/Brown	Brown/Black
15	Black/Slate	Slate/Black
16	Yellow/Blue	Blue/Yellow
17	Yellow/Orange	Orange/Yellow
18	Yellow/Green	Green/Yellow
19	Yellow/Brown	Brown/Yellow
20	Yellow/Slate	Slate/Yellow
21	Violet/Blue	Blue/Violet
22	Violet/Orange	Orange/Violet
23	Violet/Green	Green/Violet
24	Violet/Brown	Brown/Violet
25	Violet/Slate	Slate/Violet

g. All 25-pair binder groups shall be cut down in order of the following binder color:

- 1) Blue
- 2) Orange
- 3) Green
- 4) Brown
- 5) White conductors shall have a co-extruded color stripe to match its companion conductor for efficient pair identification.

4. Coded Identifiers

a. Provide coded identifiers as follows:

BCxxx	bonding conductor
BCDxxx	backbone conduit
Cxxx	cable
CBxxx	backbone cable
CDxxx	conduit
CTxxx	cable tray
ECxxx	equipment (bonding) conductor
EFxxx	entrance facility
ERxxx	equipment room
Fxxx	fiber
GBxxx	grounding bus bar
HHxxx	handhole

ICxxx	intermediate cross-connect
Jxxx	jack
LRxxx	ladder rack
MCxxx	main cross-connect
MHxxx	manhole or maintenance hole
PBxxx	pull box
SExxx	service entrance
SLxxx	sleeve
TCxxx	telecommunications closet
TGBxxx	telecommunications grounding bus bar
TMGB	telecommunications main grounding bus bar

D. Work Area Outlet Labeling Sequence and Format.:

1. Sequence: Begin labeling jacks at the teacher location WAO, or at the WAO at 18" A.F.F. immediately on the left upon entering an area.
 - a. Work clockwise around the room.
 - b. Label jacks on or above the ceiling last.
2. Each jack in Work Area Outlets shall be labeled with an identifier similar to below.
 - a. **Coordinate with the owner and verify the labeling convention desired before labeling is begun.**

D07 A-0 1 = Outlet Identifier

D XX X-XX	=	D ata or T elephone designation
X 07 X-XX	=	IDF/ICER or MDF/MERCER Room Number
X XX A -XX	=	Patch panel or cross connect block designation
X XX X- 01	=	Port number within patch panel or cross connect block

- 1) IDF/ICER Room Number shall be Owner assigned room numbers if applicable, or construction room numbers if not applicable.
 - a) **Confirm with the Owner the IDF/ICER room numbers to be used before labeling is begun.**
- 2) Each jack within outlet faceplates shall have unique numerical identifier (i.e., 1, 2, 3, 4, 5, 6). Numbering of each jack shall start at the upper most left jack, go from left to right and end at the lower most right jack. Identifier shall match the number associated on the horizontal patch in the telecommunications closet.

E. Patch Panel Labeling: Patch Panels shall be labeled with identifiers similar to below.

1. Each patch panel in a wire center shall be labeled alphabetically starting with "A".
 - a. **Label** patch panels starting from left most rack moving down and moving to the next rack to the right and down.
 - 1) Each patch panel port shall have color-coded identification label. Continuous label strips for multiple in-line ports are acceptable.
 - a) Handwritten labels will not be accepted.
 - 2) Each port on the patch panel shall be labeled with the faceplate identifier of the attached cable. For example, "A100-1".
 - 3) The above example illustrates the labeling for the patch panel port corresponding with the first data jack/cable in room A100.
 2. **Coordinate with the Owner and verify the patch panel labeling convention desired before labeling is begun.**
 3. Provide a cross-reference chart as per the TELECOMMUNICATIONS SYSTEMS DOCUMENTATION section below.
- F. 110 Field Termination Labeling: Punch Blocks shall be labeled with identifiers similar to below.
1. Each station label on the 110-type connector block shall consist of the corresponding WAO faceplate jack label.
 - a. Building automation systems shall be labeled accordingly (e.g. "FIRE.1", "FIRE.2", or "ELEV.1", "ELEV.2", ELEC PANEL 1", and do forth).
 2. Coordinate with the Owner and verify the labeling convention desired before labeling is begun.
 3. Provide all 110-binding post information as per the TELECOMMUNICATIONS SYSTEMS DOCUMENTATION below.
- G. UTP Cable Labeling:
1. Each cable shall be labeled at each end with a label tag (Thomas & Betts TY551M) identifying the corresponding Work Area Outlet faceplate jack label.
- 3.18 TELECOMMUNICATIONS SYSTEMS TESTING
- A. Cabling systems shall meet or exceed the electrical and transmission characteristics of the systems specified.
 - B. Cable segments and links shall be tested from both ends of the cable for each of the construction phases. (Verify that cable labeling matches at both ends).
 - C. Test Reports: Upon completion and testing of the installed systems for each of the construction phases, submit test reports for all systems showing all factory and field tests performed. Organize test reports by each telecommunication closet. Test reports shall be typewritten. Provide documentation and a copy of the standards being tested to. Indicate where test is in compliance and acceptable limits for the test, measured value of the test and application involved. Submit test report formats for approval during shop-drawing review.
 - D. Documentation

1. All test reports shall be submitted in hardcopy and electronic format. Hand-written test reports are not acceptable.
 1. Hardcopy reports are to be submitted in labeled, 3-ring binders with a witness signature verifying passing execution of all tests.
 2. Electronic reports are to be submitted in CD format. If test reports are in a proprietary format, the CD shall contain the software required to view test results.
 3. Electronic reports must be accompanied by a Certificate signed by an authorized representative of the Contractor, warranting the truth and accuracy of the electronic report. Certificate must reference traceable circuit numbers that match the electronic record.
 4. Test records shall be submitted ten (10) business days prior to the substantial completion date for each construction phase.
 - a. Submit one (1) copy for review by the Owner's representative.
 - b. Deliver three (3) copies to the Owner within one week of final approval.
- E. No system shall be considered certified until the tester has acknowledged, in writing, that the performance of the physical layer of the system has been fully tested and is operational at the completion of the installation phase.
- F. Equipment Manufacturer's Factory Test
1. Each cable and equipment manufacturer shall factory-test their respective products being installed on this project and provide test reports at time of delivery. Provide separate, respective test reports, indicating that products meet or exceed the latest applicable TIA/EIA Standards and technical bulletins.
 2. All other products relative to this specification shall be tested to their respective industry's strictest standards.
 3. Each manufacturer shall factory-test their respective cable or equipment provided to this project at several lower frequency levels, including the minimum and maximum frequency level indicated herein. The test reports shall indicate test results for at least five equal incremental frequency levels, including the maximum required.
- G. Field Testing Equipment: Submit during shop-drawing review, the testing equipment to be utilized on this project. The installer shall test all cables installed under this Section. Provide a hard copy of all field testing.
1. Unshielded and Shielded twisted pair Testing Equipment:
 - a. The cable-tester shall have a wide variety of preprogrammed cable types as an integral part of its testing system, and shall have the capability to test cables less than 6 feet (6ft.) from the test point.
 - 1) Cable-tester shall be NRTL-certified for TIA/EIA TSB95, Level IIE Tester for Cat 6e Cable and Level III Tester for Cat 6e Cable.
 2. Fiber Optic Test Equipment:
 - a. The cable-tester shall be NRTL-certified for compliance to latest TIA/EIA 568B Series standard and TSB72 performance requirements, at 850, 1300 and 1550 nm.
- H. UTP Cabling Systems Testing
1. All cabling shall meet or exceed Commercial Building Telecommunications Cabling Standard ANSI/TIA/EIA-586-B.2-1 for each Category type of cable installed (5e and 6e)

2. Test each UTP cable and passive component. Provide certification that entire installation of UTP cabling, equipment, and jacks are NRTL-certified, meeting or exceeding a minimum of category performance specified on all four pairs of conductors. Tests shall indicate each cable segment performance as well as each cable overall channel performance (includes patch cables at both ends of cable segments).
3. Tests shall be based on each pair of conductors and not the aggregate multiple pair results.
4. UTP Cable: Test all installed cable segments end-to-end, from the telecommunications closet horizontal patch-panel/cross-connect block panel to each Work Area Outlet, and from each [telecommunications closet backbone patch-panel/cross-connect block panel] to respective main cross-connect, and from the Work Area Outlet to the main cross-connect (through patch cables or cross-connect wiring) with a Signal Injector, Graphical Link Testing Meter and Time Domain Reflectometer (TDR) for compliance to latest TIA/EIA performance requirements, as well as NEXT, ELFEXT, structural return loss, alternating power sum, opens, shorts, continuity, cable length, and Characteristic Impedance.
5. Test reports submitted for review shall have each cable tested identified with the full jack label including room number, its associated Wire Center, rack number, patch panel and port number.
6. Test reports submitted for review shall include test results for all test parameters listed below.
 - a. Wire Map
 - b. Length
 - c. Attenuation
 - d. Near-end Crosstalk (NEXT) Loss
 - e. NEXT (Near End Cross Talk)
 - f. PS-NEXT (Power Sum Near End Cross Talk)
 - g. ELFEXT (Equal Level Far End Cross Talk)
 - h. PS-ELFEXT (Power Sum Equal Level Far End Cross Talk)
 - i. Propagation Delay
 - j. Delay Skew
 - k. Impedance
 - l. Return loss
 - m. Wire map will determine the following:
 - 1) Continuity to the remote end
 - 2) Shorts between any two or more conductors
 - 3) Crossed pairs
 - 4) Reversed pairs
 - 5) Split pairs
 - 6) Any other faulty wiring
 - n. Cable shall meet the applicable performance requirements (for the specified Category 5e and/or Category 6 Cables) in addition to the basic wire-map and length tests and all other standard Category 5e and/or Category 6 performance requirements.
 - o. Length is determined by the propagation of delay of signals, and depends on the twist-helix and dielectric materials. Note: Calibration of nominal velocity of Propagation (NVP) is critical to the accuracy of the length measurements when estimating from either frequency or time domain methods.
 - p. The maximum physical lengths for:
 - 1) Basic link = 94 meters including test equipment cords.
 - 2) Channel = 100 meters including equipment cords and patch cords.
 - 3) Test results shall be reported in feet.
 - q. Attenuation:

- 1) Link attenuation shall include all connection hardware.
- r. Near end Cross Talk (NEXT) Loss:
 - 1) Next and PS-NEXT shall be measured from both ends of the cable or link under test. For accurate measurements, at least 380 linearly-spaced sample points in a 100 MHz sweep are required.
7. When a test result is closer to the test limit than the accuracy of the field-tester, the result shall be marked with an asterisk (*). Provide documentation to interpret results marked by an asterisk.
8. The specified accuracy of the tester shall be indicated on the testing results. Limits of accuracy for the tester shall not exceed:

Random noise floor:	50-15 log (f/100 dB)
Residual NEXT:	40-15 log (f/100 dB)
Output signal balance:	27-15 log (f/100 dB)
Dynamic Accuracy:	± 1 dB
Length Accuracy:	± meter ± 4%
Return Loss:	15 dB
9. The Link test shall include all patch cables and line cords.
10. Any reconfiguration of link components after testing can change the performance of the link, and thus invalidate the previous test result. These links shall be retested.
11. In general, provide certification that all cabling and equipment installed has been tested for wire mapping, cable length, NEXT, PS-NEXT, attenuation, ELFEXT, PS-ELFEXT, Return Loss, Prop. Delay and Delay Skew, shorts, opens, polarity, split pairs, and that the pin configuration is consistent throughout the entire system. (Category 5e backbone testing shall include testing for Powersum.)
- I. Fiber Optic Cable Testing
 1. Owner reserves the right to be present during any or all testing.
 2. Testing shall be of the optical link. An optical-fiber link is defined as the passive cabling network between two optical cross-connects (patch-panels or outlets). This includes cable, connectors, and splices, but does not include active components. The link test contains the representative connector loss at the patch- panel associated with the mating of patch cords, but does not include the performance of the connector at the equipment interface. Test all fiber optic cable segments end-to-end, from the Fiber optic backbone patch panel in the main cross-connect to each Fiber optic backbone patch panel in each telecommunications closet.
 3. All cabling not tested strictly in accordance with these procedures shall be re-tested at no additional cost to the Owner.
 4. 100% of the installed cabling must be tested. All tests must pass acceptance criteria as defined below:
 - a. The Contractor must warrant in writing that 100% of the installation meets the requirements specified herein.
 - b. Owner reserves the right to conduct, using contractor's equipment and labor, a random re-test of up to five (5) percent of the cable plant to confirm documented results. Any failing cabling shall be re-tested and restored to a passing condition. In the event more

- than two (2) percent of the cable plant fails during re-test, the entire cable plant shall be re-tested and restored to a passing condition at no additional cost to the Owner.
- c. Acceptance shall be subject to completion of all work, successful post-installation testing that yields 100% PASS rating, and receipt of full documentation.
 - d. After all work has been completed, test documentation has been submitted, and Owner is satisfied that all work is in accordance with Contract Documents, the Owner shall notify the Contractor in writing of formal acceptance of the system.
5. Either the test equipment shall be fully charged prior to each day's testing or a fresh set of batteries shall be brought to the job site.
 6. Standards Compliance and Test Requirements: Unless otherwise specified, Multimode and single-mode fiber cable must meet the transmission performance parameters as specified in ANSI/TIA/EIA-568-B.3. Multimode fiber shall have core/cladding dimensions of 50/125 mm. Single-mode fiber shall be Class IVa dispersion-unshifted fiber.
 7. Testing of installed Multimode fiber cable.
 - a. Link attenuation shall be tested in accordance with ANSI/TIA/EIA-526-14A. Reference measurements shall be made in accordance with method B or equivalent. Optical loss shall be measured on each fiber at 850 nm and 1300 nm. Loss shall be measured on each fiber from each direction (bi-directionally).
 - b. Maximum Optical Loss calculations allowable for each cable at each wavelength shall include Connectors/Terminations at a value of $\leq 0.5\text{dB}$ for each connector (maximum 2).
 - c. Cabling shall meet the following loss and length criteria.
 - 1) Link length shall be optically measured Cable

Wavelength	Attenuation (dB/km)
850 nm	≤ 3.0
1300 nm	≤ 1.0
 8. Testing of installed single-mode fiber cable.
 - a. Link attenuation shall be tested in accordance with ANSI/TIA/EIA-526-7 method A. Reference measurements shall be made in accordance with method A.1 or equivalent. Optical loss shall be measured on each fiber at 1310 nm and 1550 nm. Loss shall be measured on each fiber from each direction (bi-directionally).
 - b. Maximum Optical Loss calculations allowable for each cable at each wavelength shall include Connectors/Terminations at a value of $\leq 0.5\text{dB}$ for each connector (maximum 2).
 - c. Cabling shall meet the following loss and length criteria.
 - 1) Link length shall be optically measured Cable

Wavelength	Attenuation (dB/km)
1310 nm	≤ 0.4
1550 nm	≤ 0.3
 9. Test reports shall include the following information for each cabling element tested:
 - a. Actual measured and maximum allowable attenuation (loss) at the specified wavelengths. An individual test that fails the link criteria shall be marked as FAIL.
 - b. Number of mated connectors and number of splices (if any).
 - c. Actual length and maximum allowable length. Any individual test that fails the link length criteria shall be marked as FAIL.
 - d. Group refractive index (GRI) for the type of fiber tested, if length was optically measured.
 - e. Tester manufacturer, model, serial number, and software version.
 - f. Circuit ID number and project/job name.

- g. Link criteria (Autotest) used.
- h. Overall pass/fail indication.
- i. Date and time of test.
- j. Test Equipment

- 1) All test tools of a given type shall be from the same manufacturer, and shall have compatible electronic results output.
- 2) Test equipment shall be capable of measuring relative or absolute optical power, in accordance with TIA/EIA-526-14A, "Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant," and TIA/EIA-526-7 method A, "Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant, Insertion Loss Using An Optical Power Meter."
- 3) Test equipment shall not include the loss or length of the test jumpers in the cable plant measurements.
- 4) Multimode test equipment shall incorporate both 850 nm and 1300 nm sources in same unit. The coupled output power into Multimode fiber shall be ≥ -20 dBm at each wavelength. Detectors shall have a dynamic range of at least +3 dB to -55 dB.
- 5) Sources and meters shall automatically synchronize wavelengths to prevent calibration-related errors.
- 6) Test equipment shall store at least 100 tests in internal memory.
- 7) Test equipment shall employ a serial port to facilitate uploading of saved information from tester to PC.
- 8) The time-of-flight methodology shall be employed when optically measuring fiber length.

3.19 TELECOMMUNICATIONS SYSTEMS DOCUMENTATION

A. Label all equipment as herein specified.

B. Provide:

- 1. Provide Building Telecommunications Cabling Systems Administration Report indicating TIA/EIA-606 required information.
- 2. Hard copy documentation of test results for every cable segment and link in 3-ring binder. Documents shall include measured values as well as whether or not the test passed.
- 3. "Record" drawings indicating location of all equipment, including but not limited to Work Area Outlets, patch-panels, cross-connect blocks, on each segment and cable routing. Indicate labeling for each piece of equipment.
- 4. Record drawings indicating actual cable routes and outlet identifiers. Provide respective copies mounted in each telecommunications closet and the main cross-connect.
- 5. Provide "As-built" Drawings in hard copy and in electronic format, AutoCAD Version 2000 or higher to the Owner with at least the minimum information including "required linkages", "other linkages" and "user codes" required by TIA/EIA-606 for the following:
 - a. Pathway Records
 - b. Termination Hardware Records
 - c. Space Records
 - d. Termination Position Records
 - e. Cable Records
 - f. Grounding Records
- 6. Provide "as-built" telecommunications drawings in hard copy and in electronic format, AutoCAD 2010 or higher, with the following information.
 - a. All telecommunications outlet locations identified.

- 1) All telecommunication identification labeling indicated for each connector in all outlets.
- b. All Wire Closets and Racks identified.
- c. Riser diagrams shall include:
 - 1) One-line diagrams for UTP copper cabling with cable counts.
 - 2) One-line diagrams for optical fiber cabling with cable counts.
- d. Floor diagrams shall include:
 - 1) Wire Closet locations and room numbers.
 - 2) WAO locations and faceplate labels.
 - 3) Wire Closet Wiring Zones, which identify all WAOs served.
 - 4) Horizontal cabling pathways including penetrations and fire stopping.
7. Provide a UTP patch panel information in Microsoft Excel spreadsheet format in hard copy and in an electronic file on CD cross-referencing each UTP patch panel port by wire center room, by patch panel, by port to its corresponding WAO connector label.
8. Provide all voice system 110-binding post information in Microsoft Excel spreadsheet format in hardcopy and in an electronic file on CD prior to testing and/or activation of the systems.
- C. Submit NRTL certification that the voice, data, and video-cabling systems meet the transmission requirements of TIA/EIA-568-C Series standards and TSB72.
- D. Submit NRTL certification that the fiber optic cabling system meets the transmission requirements of TIA/EIA 455, 492AAAA, TIA/EIA 568-C Series standard and TSB72.
- E. Provide installer/tester certificate indicating compliance with transmission and reliability requirements for all components of the systems installed.

3.20 TRAINING

- A. Prior to the Substantial Completion of the work, give detailed instructions to the responsible personnel designated by the Owner in the operation and maintenance of all work installed under this Section. A letter with two copies containing the name of the person or persons to whom the instructions were given, and the dates of the instruction period, shall be submitted to the Architect at the completion of the project.
- B. All training for every system shall include all applicable features, functions, programming and operations done by either the manufacturer or an authorized manufacturer's representative.
- C. Video record all training sessions and provide the recordings to the Owner.
- D. Sign-Off from Owner:
 1. The Contractor shall be required to obtain a sign-off from the Owner indicating the Owner has received proper training from the Contractor for each system specified.
- E. As a minimum, training sessions shall consist of the following:
 1. General project information and review shall be by the General Foreman or Superintendent of the Trade.
 2. Specific system training shall be by a Factory-Trained Representative.

3. Provide a complete review of the project and systems including, but not limited to, the following:
 - a. In a classroom environment, review each Record Drawing (use of typical is acceptable).
 - b. Note equipment layouts, locations, and control points.
 - c. Review each system.
 - d. Review system design, operation, and philosophy.
 - e. Review alarms and necessary responses.
 - f. Review standard troubleshooting techniques for each system.
 - g. Review areas served by equipment.
 - h. Identify color-codes used.
 - i. Review features and special functions.
 - j. Review maintenance requirements.
 - k. Review operation and maintenance manuals.
 - l. Respond to questions (record questions and answers).
4. After classroom training, walk the entire project, review each equipment room and typical locations. Explain equipment and proper operation.

F. During the instruction period the Owner and Maintenance Manual shall be used and explained.

3.21 ACCEPTANCE DEMONSTRATION

- A. Systems installed under this Section shall be demonstrated to the Owner and Architect. Demonstrations are in addition to necessary testing and training sessions. Notify all parties at least seven days prior to the scheduled demonstration. Schedule demonstrations in cooperation with, and at times convenient to, all parties, and so as to not disturb ongoing activities.
- B. Systems shall be tested prior to the demonstrations and each system shall be fully operational and tested prior to arranging the Acceptance Demonstration. Final payments will be withheld until a satisfactory demonstration is provided for all systems indicated or requested.
- C. If the demonstration is not complete, performing all functions, features and connections or interfaces with other systems, or if there is a failure during the demonstration, additional demonstrations shall be arranged. Provide and pay for all costs, labor, and expenses incurred for all attendees for each additional demonstration required for acceptance and demonstration of complete system operation.
- D. Demonstrations shall be scheduled in ample time to complete all activities prior to final acceptance and Owner occupancy. Demonstrations shall take place at least 30 days prior to the scheduled project completion date and 30 days prior to owner's use and occupancy.
- E. As a minimum, provide demonstrations for systems indicated under "Work Included" under Part One of the Specifications. Provide demonstrations of additional systems as requested by the Owner, or Architect.

3.22 PROJECT OWNER COORDINATION

- A. Prior to Substantial Completion of the project and in ample time to address and resolve any coordination issues, request and arrange meetings between the Owner, Owner's Vendors and Consultants, Architect and Construction Manager to discuss the Scope of Work for each system being provided.

- B. At these meetings, the required interface shall be reviewed with the Owner, Requests for information required to complete programming or for coordination shall be presented, and system operation and philosophy shall be discussed.

3.23 CLEANING UP

- A. Upon completion of all work and testing, thoroughly inspect all exposed portions of the installation and completely remove all exposed labels, markings, and foreign material.
- B. The interior of all boxes and cabinets shall be left clean; exposed surfaces shall be cleaned and plated surfaces polished.
- C. Repair damage to finished surfaces resulting from work under this Section.
- D. Remove material and equipment from areas of work and storage areas.
- E. All equipment shall be clean from dirt, dust, and fingerprints prior to final acceptance.
- F. Touch up all damaged pre-finished equipment using materials and methods recommended by the Manufacturer.

3.24 PROJECT CLOSEOUT

- A. Provide close-out submittals as required herein and in Section 01 77 00 – Closeout Procedures, including the following closeout submittals.
 - 1. Record Drawings with “as-built” corrections.
 - 2. “As-built” telecommunications Drawings.
 - 3. All Test Reports.
 - 4. All Warranties.
 - 5. Operation and Maintenance (O&M) Manuals.
 - 6. Copies of all sign-off and signed delivery sheets.
 - 7. Training Session Video Recordings.
 - 8. Extra Materials.
- B. Provide copies of delivery receipts. Receipts shall specifically detail what was delivered (description, quantity, and specification section) and shall be dated and signed by firm delivering materials, and by the Owner's Representative.

END OF SECTION

SECTION 274101

LARGE VENUE AUDIOVISUAL SYSTEMS
(Trade Sub-Sub-Bid Required as part of Section 26 00 00)

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SECTION 274101

LARGE VENUE AUDIOVISUAL SYSTEMS
(Trade Sub-Sub-Bid Required as part of Section 26 00 00)

PART 1 - GENERAL

1.1 TRADE SUB-BID REQUIREMENTS

- A. The Procurement and Contracting Requirements as listed in the Table of Contents, and applicable parts of Division 01 - General Requirements, shall be included in and made a part of this Section.

1.2 TRADE BID REQUIREMENTS

- A. Trade Contractor on this Project are required by law to provide Payment and Performance Bonds for the full value of his Trade Contract. Trade Contractor must include the full cost of the required Payment and Performance Bonds in the Bid price submitted to complete the Work of this Section. Trade Bids will only be accepted from Trade Contractors pre-qualified by the Awarding Authority.
- B. All Trade-Bids shall be submitted on the Trade Contractor Bid Form, included in the Specifications, in accordance with requirements of Chapter 149A of the Massachusetts General Laws, as amended.
- C. The attention of Trade Bidders is directed to Instructions to Bidders and Paragraph E of the Trade Contractor Bid Form. Trade-Bids shall be filed with the Awarding Authority in accordance with requirements stipulated therein.

1.3 RELATED DOCUMENTS

- A. All the Contract Documents, including Drawings, General Conditions, Supplementary Conditions, and all Sections of Division 01 - General Requirements, apply to the Work of this Section.
- B. The Trade Contractor for this Section shall examine all Drawings and all Sections of the Specification for requirements therein that may affect the Work of this Section, not just those Drawings and Specifications particular to the Work of this Section. The Work of this Section is shown primarily on the following listed Drawings:
 - 1. Architectural, "A" Drawings
 - 2. Electrical "E" series drawings
 - 3. Technology and Security drawings: T0-0-1 through T3-1
- C. The listing of the Contract Drawings above shall not limit responsibility to determine full extent of work of this Section as required by: all Contract Drawings noted on the Contract Drawings-Title Sheet Drawing List, the Project Manual, and Addenda.
- D. Filed Sub Bid Sub-Contractor shall also examine all other Drawings and all other Sections of the Specifications for coordination and requirements therein affecting the work of this Section, not just those pertaining particularly to this filed sub-bid.

1.4 SUMMARY

- A. Section Includes:
 - 1. Live Sound Reinforcement systems for:
 - a. Multipurpose Room
 - b. Cafeteria
 - c. Gymnasium
 - d. Weight Room
 - e. Fitness Room
 - 2. Video Presentation system equipment for:
 - a. Multipurpose Room
 - b. Cafeteria
 - c. Gymnasium
- B. Scope of Work shall include, but not be limited to:
 - 1. Video Projector Systems
 - 2. Audio-visual Matrix Switcher
 - 3. Audio-visual Switchers
 - 4. Control panels and dual-NIC control processors
 - 5. Dante-and Amplink-enabled Digital Signal Processors.
 - 6. Amplink-enabled Digital Signal processor
 - 7. Amplink-enabled networked Power Amplifiers
 - 8. Dante-enabled Mixing Consoles
 - 9. Dante-enabled and Dante—network-controllable Stageboxes
 - 10. CD/USB/AM/FM/Bluetooth Player
 - 11. CD/SD/USB Recorder/Players
 - 12. Blu-ray Players with RS-232 control.
 - 13. Remote Controls
 - 14. Assisted Listening Transceivers and Receivers
 - 15. Equipment Racks
 - 16. Two modular line-array speaker clusters (Left and Right) with front fill and dual-subwoofers per array – Black
 - 17. Point-source speakers with subwoofers – Black or White, per architect
 - 18. Ceiling speakers– Black or White, per architect
 - 19. Wired Microphones with stands, quick-release clip adapters, and XLR cables
 - 20. Dante-enabled Wireless microphones
 - 21. Wireless microphones
 - 22. Low Voltage Wiring
 - 23. Terminations
 - 24. Engraved Faceplates
 - 25. Connectors
 - 26. Interfaces to Public Address System and Fire Alarm
 - 27. Programming
 - 28. Commissioning
 - 29. Training.
 - 30. Operation and Maintenance Manuals.
 - 31. As-built Installation Documentation
 - 32. Warranties
- C. Provide and maintain in safe adequate condition all staging and scaffolding required for the proper execution of the work of this Section.
- D. Remove and re-install all ceiling tiles as required for the work of this section.

1. Replace all ceiling tiles damaged as a result of the work of this section at no cost to the owner.
 - E. Removal of all trash from site and clean up of all areas of work under this SECTION
 - F. RELATED DOCUMENTS
 - G. All of the Contract Documents, including Drawings, General Conditions, Supplementary Conditions, and all Sections of Division 01 - General Requirements, apply to the Work of this Section.
 - H. The Trade Contractor for this Section shall examine all Drawings and all Sections of the Specification for requirements therein that may affect the Work of this Section, not just those Drawings and Specifications particular to the Work of this Section. The Work of this Section is shown primarily on the following listed Drawings:
 1. Architectural, "A" Drawings
 2. Electrical "E" series drawings
 3. Technology and Security drawings: T0-0-1 through T3-1
 4. AV Drawings
 - I. The listing of the Contract Drawings above shall not limit responsibility to determine full extent of work of this Section as required by: all Contract Drawings noted on the Contract Drawings-Title Sheet Drawing List, the Project Manual, and Addenda.
 - J. Contractor shall perform daily clean-up of areas of work under this section and removal of all trash from the site.
 - K. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.
- 1.5 SYSTEM DESCRIPTIONS
- A. Sound-Reinforcement Systems: Each system shall be a complete and satisfactory operating standalone sound-reinforcement system for the pickup, amplification, distribution, and reproduction of voice and/or other audio program material.
 - B. Video Presentation Systems: Each system shall be a complete and satisfactory operating standalone video presentation system interfaced to its associated sound-reinforcement system.
- 1.6 RELATED SECTIONS
- A. Related Sections include the following:
 1. Section 26 00 00 "Electrical"
 2. Section 26 05 26 "Grounding and Bonding"
 3. Section 26 05 33 "Raceways and Boxes"
 4. Section 27 51 15 "Public Address/Intercom System"
 - B. Except for coordination, or unless otherwise indicated, the following work is not included as part of the technology Contractor's responsibilities in this SECTION, and is to be performed by others as indicated:
 1. Power Requirements provided by Electrical Contractor.

2. Costs associated with core drilling and cutting and patching, using appropriate and trained tradesmen approved by the Construction Manager and the Engineer, shall be provided by Electrical Contractor.
 3. Cutting and Patching provided by Electrical Contractor.
 4. Surface-mounted metal raceway shall be provided by the Electrical Contractor.
 5. Cable tray, ladder rack, and snake tray shall be provided by the Electrical Contractor.
 6. Sleeves and empty conduits to accessible point above ceiling or below floor shall be provided by the Electrical Contractor.
 7. Standard device boxes with plaster rings shall be provided by the Electrical Contractor.
 8. All required specialty boxes shall be furnished by the Contractor and installed by the Electrical Contractor.
 9. Public Address System shall be provided under Section 27 51 15.
- C. The installation, operating cost, and maintenance of the controlled environmental conditions for equipment located on site, as required by the manufacturer, NFPA 70B, or as specified in these specifications, shall be the responsibility of the Construction Manager.

1.7 DEFINITIONS

- A. Furnish: The term "furnish" is used to mean "supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, and similar operations."
- B. Install: The term "install" is used to describe operations at project site including the actual "unloading, unpacking, rigging in place, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations."
- C. Provide: The term "provide" means to "furnish and install, complete and ready for the intended use".
- D. SECTION, Section, and Contract: "SECTION," "Section," and "Contract" refer to the requirements of the work to be preformed as specified herein.
- E. Channels: Separate parallel signal paths, from sources to loudspeakers or loudspeaker zones, with separate amplification and switching that permit selection between paths for speaker alternative program signals.
- F. DSP: Digital Processor
- G. VC: Volume Control Unit.
- H. Zone: Separate group of speakers and associated supply wiring that may be arranged for selective switching between different channels.

1.8 PERFORMANCE REQUIREMENTS

- A. Include GENERAL CONDITIONS, SUPPLEMENTARY GENERAL CONDITIONS and applicable parts of Division 1 as part of this Section.
- B. Examine all Project Specifications and Drawings for requirements that affect work of this Section, whether or not such work is specifically mentioned in this Section.

1.9 SUBMITTALS

- A. Submit under the provisions of Division 01 Section "Submittal Procedures".

B. LEED Submittal – refer to Division 01 Sustainable Design Requirements.

1. LEED submittals are in addition to other submittals. If submitted item is identical to that submitted to comply with other requirements, submit duplicate copies as a separate submittal to verify compliance with indicated LEED requirements.
2. Project Materials Cost Data: Provide statement indicating total cost for materials used for Project.
3. LEED Action Plans: Provide preliminary submittals indicating how the following requirements will be met:
 - a. Construction Waste Management: in compliance with Division 01 Section "Construction Waste Management."
 - b. List of proposed materials with recycled content: Manufacturers certification of recycled content indicating percentage by weight of both pre-consumer and post-consumer recycled content.
 - c. Local/Regional Materials:
 - 1) Sourcing location(s): Indicate location of extraction, harvesting, and recovery of raw materials used in the products manufacturing; indicate distance between extraction, harvesting, and recovery and the project site.
 - 2) Manufacturing location(s): Indicate location of manufacturing facility; include distance between manufacturing facility and the project site.

C. Submit within (30) days of Contract award and prior to installation of any materials or equipment complete shop drawings, product data and schedule of values to the Architect for approval review.

D. Provide a Bill of Materials that clearly identifies the information requested herein for each and every item submitted. The Bill of Materials shall include the following "headings" in the order indicated from left-to-right on the Bill of Materials Index/Equipment List:

1. Item Number
2. Manufacturer's "Name" for each item
3. Manufacturer's "Model #" for each item
4. Manufacturer's "Description" of each item
5. "Specification Section Number", reference specification section number/location for the item submitted.
 - a. Example of Specification Section number/location: 2.13, B., 7., c., 4), e), page #
6. "Quantity" of each item being provided.
7. Submittal Page Number(s) of data sheet(s) for each item. Each and every specification sheet submitted shall include a page number in the lower right corner of the sheet.
 - a. Double-sided specification sheets shall be identified by two separate page numbers.

8. Bill of Material Header Example:

Item #	Mfr. Name	Mfr. #	Description	Spec Ref	Qty	Pg #
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9. All Bill of Material items shall be listed in the Bill of Material Index / Equipment List, in the same order as they appear in the specification.
10. On each and every data sheet, indicate the applicable part numbers(s) on the sheet(s) by one of the following methods:

- a. Circling the applicable part number(s)
 - b. Putting an arrow next to the applicable part number(s)
 - c. Highlighting the applicable part number(s)
 - 11. Shop drawings shall include but not be limited to the following:
 - a. Built-in station arrangement.
 - b. Equipment cabinet arrangement.
 - c. One-line drawings.
 - 12. Include in the submittal:
 - a. Warranty information for all components, including a letter from manufacturers verifying the proposed cabling and materials are eligible for a 25-year manufacturer's warranty.
 - b. Qualification Data: For qualified Contractor.
 - c. Operation and Maintenance Data: For sound-reinforcement equipment and components.
 - E. If proposed equipment deviates from the Specifications or Drawings, indicate in writing on Company letterhead those differences and provide sufficient data to justify acceptance. FAILURE TO INDICATE DEVIATIONS OR SUBSTITUTIONS IMPLIES FULL COMPLIANCE WITH DRAWINGS AND SPECIFICATIONS.
 - F. It is intended that Submittal be complete and accurate at the first submission.
 - 1. Submit all required Submittal information at one time.
 - 2. An incomplete Submittal shall be rejected in its entirety.
 - G. Minimum period of (15) working days, exclusive of transmittal time, will be required each time for review of a Submittal or Resubmittal. An additional (20) working days, exclusive of transmittal time, will be required for reviewing substitute materials or manufacturer. These time periods shall be considered by the Contractor when scheduling the work.
 - H. No equipment or material shall be used, furnished, or installed unless previously reviewed and accepted by the Architect.
 - I. Reviewed submittals on substitute equipment shall only allow the Installer to proceed with installation. The substitution shall not be considered equal until such time as the Owner and Owner's Representative have completely accepted the installation. All costs for removal, relocation, or replacement of said Substitution shall be at the risk of the Installer.
 - J. Regardless of any information included in the submittal submitted for review, the requirements of the Drawings and Specifications shall not be superseded in any way by the review. Review by the Architect does not relieve responsibility for submittal errors or from meeting the requirements of the Contract Documents.
- 1.10 SCHEDULE OF VALUES
- A. As part of the Submittal, provide a Schedule of Values.
 - B. Schedule of Values Format

1. Provide a schedule of values to be approved by Owner's representative, itemizing costs by construction phase for each technology system for labor and materials, with additional breakdowns for rough and finish work by construction phases, by system.
2. The schedule of values shall be submitted for review and acceptance prior to the paying of any invoice.
3. The schedule of values shall accurately reflect the actual costs for each category, including allocation for overhead and profit.
 - a. As a minimum, provide the following breakdown, for each system, as indicated:
 - 1) Each major piece of equipment
 - 2) Other equipment by category
 - 3) Material and labor for each item.
 - 4) Equipment installation by category and each major piece of equipment.
 - 5) Roughing work.
 - 6) Finish work.
 - 7) Bond
 - 8) Testing.
 - 9) Owner Training.
 - 10) Operation and Maintenance Manuals.
 - 11) Record Drawings.

1.11 QUALITY ASSURANCE

- A. Contractor Qualifications: Manufacturer's authorized representative who is trained and approved for installation of equipment required for this Project.
- B. The Contractor (Firm and Employees) shall be experienced in the operations they are engaged to perform.
- C. The Contractor must provide documentation as part of the submittal process that they themselves are trained and authorized for installation of all products specified.
 1. The Contractor must customarily furnish the size, scope and nature of this section and must be an authorized manufacturer's representative, certified (if certification program exist with such manufacture), experienced and qualified to provide, install, program, troubleshoot, train, warrant and service all the systems in this section in their entirety.
 2. Provide documentation (as part of the submittal process) that the Contractor is authorized by the manufacturer(s) for products to be installed as part of this Section, and are experienced and qualified to provide, install, program, troubleshoot, train, warrant and service all systems and products specified in this Section.
 3. Provide documentation (as part of the submittal process) that the Contractor holds recent, up-to-date licenses and training certificates for the equipment to be installed.
 4. The Contractor must provide (as part of the submittal process) a list of at least five projects (provide the following information for each project: name, address, contact person, title of contact person, telephone number of contact person) of similar size, scope, and nature, and demonstrate that these projects were furnished with persons on Contractor's payroll whom were experienced and qualified to provide, install, program, troubleshoot, train, warrant and service these projects satisfactorily.
 - a. For each project listed by the Contractor, provide the following information:
 - b. List all the systems and products provided for the project.
 - c. Manufacturer's name and model number of each system provided on the project.
 - d. Manufacturer's telephone numbers.

- e. Documentation signed by the manufacturer indicating that the Contractor is an authorized dealer or installer for the systems or products specified.
 - f. A valid certificate of completion of installation and service training from each applicable manufacturer for a present employee of the Contractor.
- D. Testing Agency Qualifications: Qualified agency, with the experience and capability to conduct testing indicated.
- E. Source Limitations: Obtain public address and mass notification systems from single source from single manufacturer.
- F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- G. Comply with NFPA 70.
- H. Comply with UL 813 unless a more stringent standard is specified in Part 2.

1.12 COORDINATION

- A. Coordinate quantity and arrangement of speaker assemblies with ceiling space configuration and with components occupying ceiling space, including structural members, pipes, air-distribution components, raceways, cable trays, recessed lighting fixtures, and other items.

1.13 INTERPRETATION OF DRAWINGS

- A. All work indicated on the Drawings is intended to be approximately correct to scale, but figures, dimensions, and detailed Drawings are to be followed in every case. The Drawings shall be taken in a sense as diagrammatic. Size of raceways and methods of running them are indicated, but it is not intended to show every offset and fitting, nor every structural difficulty that may be encountered.
- B. Mounting locations of loudspeakers indicated on the Drawings are specific. Locations indicated on the Drawings of other equipment are approximate, and it is intended that all equipment shall be located in accordance with the general and detail Drawings of the construction proper. Coordinate the location, mounting heights, and routing of cabling work with other trades' requirements and with field conditions.
- C. All measurements shall be taken at the building before fabrication commences.
- D. Schematic diagrams shown on the Drawings indicate the required functions. Standard diagrams of the manufacturer may be used for the functions indicated without exact adherence to the Schematic Drawings shown. Work required for such deviations shall be provided.
- E. Items referred to in singular number in Contract Drawings shall be provided in quantities necessary to complete work.
- F. The right is reserved to make reasonable changes in locations of work prior to rough-in at no additional cost.
- G. Where Drawings or Specifications conflict or are unclear, advise the Architect in writing before Award of Contract. Otherwise, interpretations of Contract Documents by the Architect shall be

final, and no additional compensation shall be permitted due to discrepancies or ambiguities that are resolved according to the Architect's interpretation.

- H. Drawings and Specifications form complimentary requirements. Provide work indicated on the Drawings, but not specified; and work specified, but not indicated on the Drawings as though explicitly required by both.
- I. Drawings and Specifications do not undertake to indicate every item required to produce a complete and properly operating installation. Materials, equipment, or labor that is not indicated, but that can be reasonably inferred to be necessary for a fully complete, secure, and properly operating installation suitable for the intended use, shall be provided.
- J. Drawings do not limit responsibility of determining full extent of work required by Contract Documents. Refer to all Drawings and Specifications that indicate types of construction in which work shall be installed, and work of other trades with which work of this Section must be coordinated.
- K. Except where modified by a specific notation to the contrary, it shall be understood that the indication or description of any item, in the Drawings or Specifications or both, carries with it the instruction to provide the item, regardless of whether this instruction is explicitly stated as part of the indication or description.
- L. Where Drawings or Specifications do not coincide with manufacturer's recommendations, or with applicable Codes and Standards, alert the Architect in writing before installation. Otherwise, make changes in installed work as the Architect requires without additional cost.
- M. It is the intent of these Contract Documents to have systems and components that are fully complete and operational, and fully suitable for the intended use. There may be situations in the documents where insufficient information exists to precisely describe a certain component or subsystem, or the routing of a component. In such cases, where the Contractor has failed to notify the Architect in writing of the situation prior to Contract Award, the Contractor shall provide the specific component or subsystem with all parts necessary for the intended use, fully complete and operational, and installed in workmanlike manner, either concealed or exposed per the design intent.
- N. In situations where potential conflict exists, or where the Contractor believes guidance is required, submit a sketch identifying proposed solution, and the Architect shall review, note if necessary, and return this sketch appropriately marked for use by the Contractor.

1.14 OBTAINING INFORMATION

- A. Obtain from the manufacturer the proper method of installation and connection of the equipment that is to be furnished or installed. Obtain all information that is necessary to facilitate the work and to complete the project. Include all such information in Operation and Maintenance Manuals.

1.15 PERMITS, FEES, RULES AND REGULATIONS

- A. Give the proper Authorities all requisite notices or information relating to the work under this Section. Obtain and pay for all fees, licenses, permits and certificates. Comply with the rules and regulations of all local, state, and federal authorities having jurisdiction, Building Codes, the rules and regulations of the National Board of Fire Underwriters, and the public utility companies serving the building.

- B. Public utility back charges will be paid for by the Owner and are not to be included in the base bid. Markups on utility back-charges will not be allowed.
- C. Perform work in accordance with Nationally Recognized Testing Laboratory (NRTL) listing or labeling requirements, OSHA regulations, NFPA Standards, Electrical Code, the Americans with Disabilities Act Accessibility Guidelines (ADAAG), EIA/TIA, and BICSI. The Drawings and Specifications do not attempt to indicate all work required by codes, regulations, and authorities.
- D. Nothing in these Contract Documents shall be construed to permit work not conforming to applicable codes and regulations. When conflicts occur, the more restrictive requirements shall govern.
- E. Toxicity: Comply with applicable codes and regulations regarding toxicity of combustion products used or hazardous materials used, or disposed of.
- F. Legally dispose of all material. Adhere to all regulations regarding disposal of hazardous material. Recycle hazardous material where recycling is possible. Submit certificates of legal recycling or disposal to the Architect. Include copy in the Owner and Maintenance Manual.
- G. Should the Facility have established building standards, rules, or regulations, obtain a copy from the Building Owner, and comply with them.

1.16 DELIVERY, STORAGE, AND HANDLING:

- A. Do not deliver items to the site until all specified submittals have been submitted to, and approved by, the Architect.
- B. Deliver materials in original packages, containers, or bundles bearing brand name, or identification of manufacturer or supplier.
- C. Deliver, store, protect, and handle products in accordance with recommended practices listed in Manufacturer's Installation and Maintenance Manuals.
- D. Protect materials from damage due to moisture, direct sunlight, excessive temperatures, surface contamination, corrosion, and damage from construction operations and other causes.

1.17 PROTECTION OF WORK AND PROPERTY

- A. Be responsible for the care and protection of all work included under this Section until it has been tested and accepted.
- B. Protect all equipment and materials from damage from all causes, including theft. All materials and equipment damaged or stolen shall be replaced with equal material or equipment at the option of the Architect and Owner.
- C. Materials and equipment stored for this project shall be protected and maintained according to the manufacturer's recommendations and requirements, and according to the applicable requirements of NFPA 70B.
- D. Protect all equipment, outlets and openings with temporary plugs, caps and covers. Protect work and materials of other trades from damage that might be caused by work or workmen, and make reparations for any damage caused.

- E. Use caution to avoid damage to existing work, and to prevent harm to personnel working in all areas.
- F. Observe all safety precautions and requirements for the construction.
- G. When open-flame or spark-producing tools, such as blower torches, and welding equipment, are required in the process of executing the work, the Construction Manager shall be notified not less than twenty four hours in advance of the time that the work is to begin and the location where the work is to be performed. Provide, where necessary, fire protective covering and maintain a constant non-working fire watch where work is being performed, and until it is completed.
- H. The Construction Manager and the Contractor are responsible for initiating, maintaining, and supervising all safety precautions and requirements during construction.

1.18 MATERIAL AND EQUIPMENT STANDARDS

- A. Manufactures:
 - 1. Manufacturers are listed for the purpose of establishing a specification standard for that particular item. Other manufacturers shall be considered for approval, provided they meet or exceed all the specification requirements.
- B. Except where no substitutions are indicated, where materials or equipment are specified by patent proprietary name, or name of the manufacturer, such specification is used for the purpose of establishing a standard for that particular item. If more than one manufacturer is listed, the Contract Documents are based on the first manufacturer listed, and every other manufacturer is considered a substitution.
- C. If three or more manufacturers are indicated without the term "or equal", or "or approved equal", then the material and equipment shall be supplied by one of those indicated and that material and equipment shall conform in all respects to the Drawings and Specifications.
- D. No equipment or material shall be used, furnished, or installed unless previously reviewed and accepted by the Architect.
- E. Substitutions may be offered for review, provided the material, equipment, or process offered for consideration is equal in every respect to that indicated or specified. The request for each substitution must be accompanied by a letter from an Authorized Representative of the manufacturer and the Contractor, indicating that the substitution meets or exceeds all specified requirements. Provide complete specifications, drawings, or samples to properly appraise the materials, equipment, or process. Acceptance of substitutions shall be based on performance, appearance, use, maintenance requirements, durability, aesthetics, physical arrangement, size, and quality.
- F. If a substitution of materials or equipment, in whole or in part, is made, bear the cost of any changes, engineering, or construction, necessitated as a result of said substitution.
- G. Materials shall be new, unused, of recent manufacture, not previously installed, full weight, standard, the best quality of its kind, and acceptable to the Architect.
- H. Provide NRTL-listed or labeled products whenever there are NRTL standards, listings, or labeling available for that product category.

- I. The Specifications or notes and description following a catalog number is basically to identify the item, but may also call for accessories, options, or modifications that are not indicated in the catalog number.
- J. Reviewed submittals on substitute equipment shall only allow the Contractor to proceed with installation. The substitution shall not be considered equal until such time as the Architect and Owner's Representative have completely accepted the installation. All costs for removal, relocation, or replacement of said Substitution shall be at the risk of the Contractor.
- K. Provide products of one manufacturer for each classification of equipment.
- L. Provide documentation from both specified Product Manufacturer and the proposed substitute Product Manufacturer with separate comparative analysis sheet that matches product specification item for item. Substitutes shall not be considered unless accompanied by this documentation.

1.19 SEQUENCING AND SCHEDULING

- A. Coordinate the work of this Section with the respective trades responsible for installing interface work and ensure that the work performed hereunder is acceptable to such trades for the installation of their work.
- B. Refer to the overall scheduling of the work of the project. Schedule work, process Submittal and order materials and equipment to conform to this schedule, and install work to not delay nor interfere with the progress of the project.
- C. Inform Architect immediately of any delays or potential delays. Furnish manufacturer's letter to verify order date, equipment delays, expected shipment date, order number, and potential remedies to speed up delivery. Any costs to speed up delivery shall be implemented at no cost to the project if the equipment or material was not ordered as soon as possible after Contract award or within the time frames indicated with the Submittal.
- D. Include premium time required to comply with the project scheduling and phasing.
- E. Be aware of, and plan for, project scheduling and phasing. Provide for complete continuous operation of all systems. Coordinate scheduling and phasing with the Architect, Owner, other Trades, and the Construction Manager.

1.20 WARRANTY

- A. Provide a warranty for two years against defects in material and workmanship on all components, equipment, software, systems, and cabling specified. Warranty shall start at time of substantial completion or routine use, whichever comes first. Warranty shall include all materials, equipment, and work furnished or installed under this Section. Any failure due to defective material, equipment, installation, or workmanship that may develop shall be corrected at no expense to the Owner, including all materials, labor, travel, expenses, system diagnostics, and damage to areas, materials, and other systems resulting from such failures.
- B. Manufacturers shall provide replacement warranties for material and equipment furnished under this Section. Such warranties shall be in addition to and not in lieu of, all liabilities that the Manufacturer and the Contractor may have by law or by provisions of the Contract Documents.

1.21 MAINTENANCE

- A. Provide a maintenance contract quote upon request, for a period equal to warranty.
- B. Upon receipt of notice from the Owner of failure of any part of the systems during the warranty period, the affected parts shall be replaced. Any equipment requiring excessive service, consisting of more than two unscheduled service calls, shall be considered defective and shall be replaced.
 - 1. Response times to warranty issues shall differ according to the level of the problem.
 - 2. A problem is considered to be corrected when the system and its components operate according to specified requirements.
 - 3. Warranty work shall be performed according to the procedures of the Owner, its staff and tenants, and their normal operations.
 - 4. The following levels of response to problems are required:
 - a. Major Failure: 4-hour maximum response time if notified by telephone, 24 hours per day, 365 days per year.
 - b. Minor Failure: 24 hours maximum response time if notified by telephone, 365 days per year.
 - 5. Failures are defined as follows:
 - a. Major Failure: a system failure that disables the entire system or major part of the system, or an individual critical piece of equipment that prevents the proper operation of more than one system component.
 - b. Minor Failure: a system failure that affects only one non-critical component and does not affect operation of any other components or any failure that is not defined as a major failure.
 - c. Major and minor failures are as defined by the Owner.
 - 6. Response time to a call is defined as the time at which a qualified technician arrives at the site and starts repairs or diagnostics. If the problem has not been corrected within two hours of the initial response, regional and/or national support personnel shall be contacted for assistance.
- C. Adequate stocks of parts, components, and access to regional and national support personnel shall be available such that all major failures shall be corrected within 8 hours of Owner's initial telephone call, and all minor failures within 48 hours. Temporary components may be used to meet this requirement while new components or repairs are completed. Temporary components shall be replaced with new (unused) components or the original component repaired as soon as practical. Remanufactured equipment or components are not considered new and shall not be used.
- D. Provide certified factory-trained technical service personnel for service and maintenance of the system.
 - 1. Provide a copy of this warranty section in the Operations and Maintenance Manuals. Each copy shall be dated, signed, and certified by an authorized Representative of the Contractor providing work under this Section stating that these requirements are understood and will be complied with without exception.

1.22 CERTIFICATES OF APPROVAL

- A. Upon completion of all work, and as a condition to receiving payment at Substantial Completion, furnish to the Architect the following original, signed certificates, and include copies of these certificates as part of the Operation and Maintenance manuals:
1. Certification from the manufacturer's authorized representative stating that authorized factory engineers have inspected and tested the operation of their respective equipment and found same to be installed in accordance with the manufacturer's requirements, all requirements for manufacturer's warranties are complied with, and equipment is in satisfactory operating condition. This certification shall be provided for each piece of major equipment and for all complete systems. Provide certificate for additional items requested by the Architect.
 2. Certificates of inspection, letters, or notices from the appropriate governmental authorized inspection authorities stating that all portions of the work (indicate trade and responsibility) have been inspected, and are installed in conformance with the applicable codes, laws, ordinances, and referenced standards. If non-conformance notices are received, include the re-inspection certificate, letter of explanation as required to indicate complete conformance. Provide written evidence of all exceptions or variances given by any Inspector.
 3. Certificate from the installing firm responsible for the work (indicate trade and responsibility) signed by an authorized Officer of the firm and the Foreman or Project Manager in charge, indicating trade license numbers and stating that to the best of the signer's knowledge and belief that the project (indicate project name and address) has been installed in compliance with the Contract Drawings, Specifications, and Addenda, and all applicable codes, laws, ordinances, and referenced standards. Where sub-contractors perform a portion of the work of this Section, include certificates from them.

1.23 SUBSTANTIAL AND FINAL COMPLETION

- A. Refer to General Conditions and Supplementary Conditions.
- B. Substantial Completion shall not be considered unless all systems are tested and verified for adherence with Contract Documents and any work remaining is less than one percent of the total Contract Value of this Section.
1. Record Drawings, Operation and Maintenance Manuals, Acceptance Demonstrations, Owner personnel training, spare parts or extra materials required, test reports, warranties and certifications of installation inspections shall be submitted and accepted prior to Substantial Completion.
- C. Final Completion shall be when all work under this Section is completed as defined by the Contract Documents and accepted by the Architect.
- D. Upon completion of all work under this Section, submit written certifications that:
1. Contract Documents including addenda, clarifications, change orders, RFIs, and instructions from Architect have been reviewed.
 2. Work has been inspected for compliance with Contract Documents.
 3. Work has been completed in accordance with Contract Documents, and any deficiencies listed with Certificate of Substantial Completion have been corrected.
 4. Equipment and systems are fully operational.
 5. Work is complete and ready for Architect's final review.
- E. When Architect determines Work is complete, close out submittals will be considered.

1.24 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS

- A. At least (30) days prior to Substantial Completion, submit for review three sets of Operating and Maintenance Manuals containing Manufacturer's catalogs, and other similar data, including the necessary photographic equipment cuts, wiring diagrams and final reviewed Shop Drawings and Product Data covering all equipment and devices furnished or installed under this Section. These manuals shall provide complete instructions for the proper operation and use of the equipment together with instructions for lubrication and periodic maintenance, and for trouble shooting. Operating instructions shall be specific for each system and shall include copies of posted specific instructions. This manual shall contain only information that specifically applies to this project, and all unrelated material shall be deleted or clearly crossed out.
- B. The Owner and Maintenance Manual material shall be bound in 3-ring binders and indexed.
 - 1. On the edge of the binder provide a clear see-through plastic holder with a typed card indicating the Project name, the Architect's name, the Contractor's name and the Volume number (e.g., Vol. No. 1 of 2).
 - 2. Index shall identify the page number(s) or section divider number for each item.
 - 3. The Owner and Maintenance Manual Index column headings shall identify the following minimum information. Manuals must be submitted using the following "headings" in the order indicated from left-to-right on the Index:
 - a. "Description" of each item
 - b. "Manufacturer's" Name for each item
 - c. Manufacturer's "Model #" for each item
 - d. Owner and Maintenance Manual "Page" Number(s) or "Section" Divider Number for each item.
- C. Provide name, address, and telephone number of the manufacturer's representative and service company for all items supplied, so that the source of replacement parts and service can be readily obtained.
 - 1. Include copies of manufacturer's and Contractor's warranties and maintenance contracts, and performance bonds properly executed and signed by an authorized representative.
- D. Include copies of all test reports and certifications.
- E. Include copies of all Warranties.

1.25 LOOSE EQUIPMENT

- A. Turn over all loose equipment to the owner.
- B. Provide documentation of loose equipment and locations.
- C. Obtain and submit written sign-off itemizing all loose equipment turned over as part of the Close-Out documentation.

1.26 SEISMIC REQUIREMENTS

- A. Equipment and work shall meet the restraint requirements for a Seismic Zone - 2 location, including installation and connections of material and equipment to the building structure.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide a complete and satisfactory operating standalone live sound-reinforcement system in each of the following areas for the pickup, amplification, distribution, and reproduction of voice and/or other audio program material
1. Multipurpose Room
 2. Gymnasium
 3. Cafeteria
 4. Weight Room
 5. Fitness Room
- B. Provide a complete and satisfactory operating standalone video presentation system interfaced to the associated live sound-reinforcement system in each of the following areas.
1. Multipurpose Room
 2. Gymnasium
 3. Cafeteria
- C. All equipment, except portable equipment, shall be held firmly in place. This shall include all loudspeakers and amplifiers. Fastenings and supports shall be adequate to support their loads with a safety factor of at least three.
1. All switches, amplifier equipment, and microphone outlets shall be clearly, logically, and permanently marked using proper size engraved, laminated-plastic name tags fastened with screws for a permanent type of adhesive. In order to protect the owner and to insure the availability of warranty service and parts, the installing supplier shall be a factory-authorized representative for the products being supplied. A letter authorizing representation shall be supplied and included in the submittals. Any substitutions shall be requested in writing to the architect and the owner ten days prior to bid.
 2. Any request for substitution shall include detailed manufacturers data to substantiate that the proposed product is equal to the one specified. The Contractor shall provide the owner and architect with an assurance that the proposed substitute is equal in sound quality, function, and appearance to the one specified and demonstrate the ability of the Contractor to properly install and tune an equal system in the manner specified later in this section.
 3. Construction Manager responsibilities:
 - a. Provide painting of sound system devices, surface conduit, and surface back boxes to match surroundings as required.

2.2 MULTIPURPOSE ROOM

- A. Provide products as listed or approved equals.

Qty	Manufacturer	Model	Description
2	AKG	C451 B	Reference small-diaphragm condenser microphone
2	Atlas Sound	SMS2B	Desktop Stackable Mic Stand 6" Ebony
2	Atlas Sound	SMS5B	Stackable Mic Stand with 10" Round Base

Qty	Manufacturer	Model	Description
1	Bogen	PRS40C	Power supply for Bogen VAR1, 12VDC/300 mA
1	Bogen	VAR1	Voice-Activated Relay, 70V speaker-level input, 600-ohm and relay output
1	Bose	ESP-1240AD	12-input, 4-output sound processor with Dante and Amplink
4	Bose	Panaray 620M	Panaray 620M Floor Array, 120 x 40 degree coverage
7	Bose	PowerMatch AmpLink 24-Channel Card	PowerMatch AmpLink 24-Channel Card
7	Bose	POWERMATCH PM8500N	8-channel amplifier, 500W per channel, network controllable and configurable, speaker presets for Bose speakers, card-slot expansion capable of accepting Amplink card
2	Bose	RMU108	8 Ohm loudspeaker, single 8-inch woofer, 121 dB peak SPL, 80 Hz - 16 kHz, 1000W peak
2	Bose	ShowMatch SM10	Bi-amplified line-array loudspeaker, -3dB from 69 Hz - 16 kHz, 1800W/400W peak (LF/HF), 127 dB/132 dB peak (LF/HF). Asymmetric field-replaceable waveguides
1	Bose	ShowMatch SM20	Bi-amplified line-array loudspeaker, -3dB from 69 Hz - 16 kHz, 1800W/400W peak (LF/HF), 127 dB/132 dB peak (LF/HF). Asymmetric field-replaceable waveguides
3	Bose	ShowMatch SM20	Bi-amplified line-array loudspeaker, -3dB from 69 Hz - 16 kHz, 1800W/400W peak (LF/HF), 127 dB/133 dB peak (LF/HF). Asymmetric field-replaceable waveguides
6	Bose	ShowMatch SM5	Bi-amplified line-array loudspeaker, -3dB from 69 Hz - 16 kHz, 1800W/400W peak (LF/HF), 127 dB/133 dB peak (LF/HF). Asymmetric field-replaceable waveguides
4	Bose	SM20WG12	Loudspeaker Waveguide for SM20
2	Bose	SMAF Array Frame	ShowMatch Array Frame, additional misc. rigging hardware required but not included
2	Bose	SMAFT	ShowMatch T-Bar Array Frame, additional misc. rigging hardware required but not included
4	Bose	SMS118	Subwoofer, ShowMatch compatible mounting hardware, 29 Hz - 300 Hz, 3000W peak, 127dB peak
1	Chief	CMA345	Structural Ceiling Plate
1	Chief	CMA347	Vibration Damper Mount
1	Chief	CMS012018	Adjustable Pipe, 18 to 24 inches
1	Chief	CMSxxx	Fixed pipe of appropriate length

Qty	Manufacturer	Model	Description
1	Chief	VCMU	Heavy Duty Universal Projector Mount
8	Clear-Com	CC-40	Single-ear economy headset XLR-4F
1	Clear-Com	HLI-ET2	HelixNet Ethernet module
1	Clear-Com	HMS-4X	HelixNet digital 12-ch. Head-set/speaker main station
8	Clear-Com	HXII-BP-X4	HelixNet digital 2 Ch. dual listen monaural beltpack
2	Comprehensive	CAT6-25PROBLK-EE	CAT6 cable, black, NE8MC terminations on each end, 25ft
1	Comprehensive	MPS-MPS-6ST	3.5mm Stereo Mini Plug to Plug Audio Cable, 6ft
11	Comprehensive	XLRP-XLRJ-15ST	24 gauge 0.236" diameter XLRM to XLRF cable, 15ft
2	Comprehensive	XLRP-XLRJ-18INST	24 gauge 0.236" diameter XLRM to XLRF cable, 18in
11	Comprehensive	XLRP-XLRJ-25ST	24 gauge 0.236" diameter XLRM to XLRF cable, 25ft
4	Custom (TBD)	Audio Wall Plate	See Drawing
2	Custom (TBD)	Ceiling Mic Plate	See Drawing
4	Custom (TBD)	Control Panel Wall Plate	See Drawing
1	Custom (TBD)	FSR Floor Box	16 XLR-F, 4 XLR-M floor box, See Drawing
4	Custom (TBD)	Intercom Wall Plate	See Drawing
2	Custom (TBD)	Monitor Wall Plate	See Drawing
1	Custom (TBD)	Rack Plate	See Drawing
1	Da-Lite	70276	16:10 120" x 192" or 226" Diagonal, HD Prograssive 1.1 Contrast surface, electric tensioned, low-voltage control, black case
1	Denon Pro	DN-500BDMKII	Blu-Ray, DVD & CD/SD/USB Player, RS-232 control
1	Epson	ELPLL08	Epson's Long Throw Zoom Lens is an interchangeable lens that works with the PowerLite Pro G7XXX Series and Pro LXXXX Series projectors (excludes Pro L25000).
1	Epson	L1505UHNL	Pro L1505UHNL WUXGA 3LCD Laser Projector with 4K Enhancement Without Lens, 12,000 lumens, HDBaseT input
1	Extron	DTP T HD2 4K 230	DTP Transmitter for HDMI with Input Loop-Through
1	Extron	HAE 100 4K	HDMI Audio De-Embedder..
7	Extron	HC 403	Meeting Space Collaboration System – Decorator-Style Wallplate transmitter (Black) with VGA and HDMI, half-rack receiver with HDMI input and output, control processor with contact closure
7	Extron	HCR 102	Scaling receiver included in HC 403

Qty	Manufacturer	Model	Description
7	Extron	HCT 102 D	Decorator-Style Wallplate transmitter (Black) included in HC 403
1	Extron	IPCP PRO 360	IP link pro control processor, dual NIC
1	Extron	IPL Pro CR88	IP Link Pro Control Processor with contact closure outputs
1	Extron	MBU 123	Low-Profile Mount Kit for 1/8 and 1/4 Rack Width Products
1	Extron	PS 1210 P	[NB] - 12V, 1A, Connector DC Plug Power Supply
5	Extron	RSU 126	1U 6" Deep Universal Rack Shelf Kit
1	Extron	RSU 126	1U 6" Deep Universal Rack Shelf Kit with Extron mounting holes
1	Extron	SW8 HD 4K	Eight Input HDMI Switcher
1	Extron	TLP Pro 1025M	10" Wall Mount TouchLink Pro Touch-panel
3	Extron	TLP Pro 1025T	10" Table-Top TouchLink Pro Touch-panel
2	Listen Technologies	LP-41-072-01	Intelligent DSP RF receiver 12-pack (72 MHz) (charging tray included)
1	Listen Technologies	LS-55-072	Listen iDSP Prime Level III Stationary RF System (72 MHz)
1	Middle Atlantic	BR1	Brush grommet panel, 1 space
5	Middle Atlantic	D2LK	Anodized drawer with lock, 2 space
16	Middle Atlantic	J-12	12" jumper, connects power modules
2	Middle Atlantic	LBP-1A	L-Shaped horizontal lacer bar, pack of 10
1	Middle Atlantic	LT-GN-PNL	Dual gooseneck light with rackmount panel
9	Middle Atlantic	M-2X20IGA	8" MPR module 20A double duplex isolated ground
2	Middle Atlantic	MPR-8A	Modular power raceway, 72" long
2	Middle Atlantic	MW-4FT-380CFM	Fan Top kit for WR-44-42, 380 CFM
2	Middle Atlantic	PD-920R-SP	9 outlet, 20A, surge suppressor, 100V-135V, Listed to UL standard 1283 and 1449
7	Middle Atlantic	RLM-20IGA	Switchable power module, 8" long, 20 amp, isolated ground
2	Middle Atlantic	T-80	Tails for MPR modules, 80", Connector On One End
1	Middle Atlantic	TD8FLK	Anodized drawer with lock, 8 space
1	Middle Atlantic	UPS-2200R-8IP	UPS, 8-outlet, 2150VA/1650W, pure sine wave output
2	Middle Atlantic	WR-44-42	44 Space, 42" depth multi bay, WRK
2	Middle Atlantic	WR-RAP-44	Rear Access Panel, 44 RU WR Racks
2	Middle Atlantic	WR-RR-44	Rackrail, 10-32, 44 RU, WR Series
1	Pakedge	SX-24	8-Port Managed Switch with rack mount, optimized for Dante/AVB with web-based GUI configuration

Qty	Manufacturer	Model	Description
2	Pakedge	SX-24P	8-Port Managed Switch with rack mount, 24 ports PoE or up to 12 ports PoE+, optimized for Dante/AVB with web-based GUI configuration
8	Point Source Audio	C0-8WL-XSH-BL	Omnidirectional condenser lavalier microphone w/ TA4F connector for Shure, IP 57 waterproof rated, 20 Hz - 20 kHz, 136 dB SPL max, +/- 1dB from 50 Hz to 10 kHz, Black
8	Point Source Audio	CR-8D-XSH-BE	Cardioid small-diaphragm Headset Microphone with interchangeable TA4F connector for Shure transmitters in beige, 160 Hz - 14kHz, 135dB SPL max input
1	Shure	CVG12-B/C	Cardioid-12" Dual-Section Gooseneck Condenser Microphone, Inline Pre-amplifier, Flange Mount, Black
18	Shure	SB900A	Lithium-Ion Rechargeable Battery for Shure ULXD
1	Shure	SBC200-US	2-bay Shure Battery Charger. Works with SB900A, PSM®900, PSM®1000, UR5 Portable Diversity Receiver, and ULX-D® Digital Wireless Systems.
2	Shure	SBC800-US	8-Bay Shure Battery Charger. Works with SB900A, PSM®900, PSM®1000, UR5 Portable Diversity Receiver, and ULX-D® Digital Wireless Systems.
2	Shure	SCM820-DAN	8-Channel Digital IntelliMix Automatic Mixer with Dante
6	Shure	SM57-LC	Dynamic microphone with R57 cartridge
2	Shure	UA864US	Wall-mounted wideband wireless microphone antenna
16	Shure	ULXD1	Digital Wireless Bodypack Transmitter with Miniature 4-Pin TA4M Connector for use with ULXD systems
2	Shure	ULXD2/B58	Beta 58 Wireless Transmitter for use with ULXD systems
4	Shure	ULXD4Q	Quad digital wireless receiver with internal power supply, 1/2 wave antenna and rack mounting hardware, Dante primary and secondary redundancy capability
1	Tascam	SS-CDR250N	CD/SD/USB recorder/player with balanced audio input/output, RS-232 and LAN control
1	Whirlwind	PCDI	Stereo direct-injection box with RCA and 3.5mm unbalanced inputs, rugged housing for use on-stage
4	Whirlwind	SK550G12	50' Speaker Cable, 12AWG with NL4F Speakon Connectors
2	Whirlwind	SPC82	8-channel transformer Mic Splitter
1	Yamaha	DANTE-MY16-AUD	Dante to Card-Frame converter

Qty	Manufacturer	Model	Description
1	Yamaha	NY64-D	Dante Interface Card for Yamaha TF Console
1	Yamaha	RSIO64-D	Dante primary and secondary to Card-Frame converter, capable of providing routing of Dante audio between two independent pairs of redundant networks
1	Yamaha	TF5	Digital Mixing Console, 32 local analog inputs, Dante primary and secondary connections, remote control of Dante-enabled stage-boxes, controllable via LAN by compatible software
2	Yamaha	TIO1608-D	16 in x 8 out Out Digital Stage Box for the TF Series Mixing Consoles, Dante primary and secondary network connections, controllable via Dante network

2.3 GYMNASIUM

A. Provide products as listed or approved equals.

Qty	Mfr.	Model / Part #	Description
Assistive Listening			
1	Listen Technologies	LP-41-072-01	Intelligent DSP RF Receiver 12-Pack (72 MHz)
1	Listen Technologies	LT-800-072-P1	Stationary RF Transmitter Package 1 (72 MHz)
Audio			
2	Attero Tech	unD6IO	4x2 Multi-IO Dante Wall Plate Interface
1	Attero Tech	unD6IO- BT	Dante™ Networked Audio Wall Plate - 4x2 Multi I/O with Bluetooth® Audio - White
1	Bose ControlSpace	EX-1280 Processor	Processor includes 12 mic/line analog inputs, 8 analog outputs, 8 AmpLink digital outputs, 64x64 Dante™ and a flexible, open architecture signal processing.
16	Bose	DM8S White	Delivering SPL suitable for foreground music, the 125-watt DesignMax DM8S loudspeaker features a two-way, 8-inch coaxially mounted woofer and a center-firing 1-inch compression driver - White
1	Bose PowerSpace	P21000A	2-Channel 1000W Versatile Power Amplifier with Amplink
2	Comprehensive	XLRP-XLRJ-50ST	Standard Series XLR Plug to Jack Audio Cable 50ft
2	Shure	SB900A	Lithium-Ion Rechargeable Battery

Qty	Mfr.	Model / Part #	Description
1	Shure	SBC200-US	Dual Docking Charger with Power Supply
1	Shure	SM58S	Cardioid Dynamic, On-Off Switch
1	Shure	SM58	Cardioid Dynamic
1	Shure	ULXD1	Digital Wireless Bodypack Transmitter with Miniature 4-Pin Connector
1	Shure	ULXD2/SM58	Microphone Handheld Wireless Transmitter
1	Shure	ULXD4D	Dual digital wireless receiver with internal power supply, 1/2 wave antenna and rack mounting hardware
1	Shure	WL185	Wireless premium condenser lavalier mics for speech applications.
Cables and Connectors			
2	Comprehensive	CAT6-7PROBLK	Pro AV/IT Cat6 Cable, RJ45 Male to RJ45 Male Heavy Duty Patch Cable - Black 7ft - 550 Mhz
2	Comprehensive	HD18G-12PROBLK	Pro AV/IT Certified 18Gb 4K High Speed HDMI Cable with ProGrip 12ft Black
1	Comprehensive	MHD18G-3PROBLK	MicroFlex Pro AV/IT Certified 4K60 18G High Speed HDMI Cable with ProGrip Jet Black 3ft
1	Comprehensive	MHD18G-6PROBLK	MicroFlex Pro AV/IT Certified 4K60 18G High Speed HDMI Cable with ProGrip Jet Black 3ft
Control			
1	Extron	SMK 2 - White	Surface Mount Kit for TLP Pro 725M and TLS 725M - White
1	Extron	TLP Pro 725M-White	7" Wall Mount Touchlink Pro Touchpanel - White
1	Honeywell	CG511A	Touch Panel Security Cover
1	Pakedge	MS-1212	Pakedge® MS Series Layer 3 Managed Switch with OvrC 12 1G PoE+, 190W, 2 10G SFP+
Display			
1	Bretford	TC15F-BK	19" Rack Cart (Black)
1	Panasonic	ET- EMT700	2.10 4.14:1 Zoom lens for PT-MZ16K/MZ13K/MZ10K
1	Panasonic	PT- MZ16KU	WUXGA 1920 X 1200 16000 LMNS LCD Laser Projector No Lens
Equipment Rack			
1	Middle Atlantic	DWR- 18-22	DWR sectional wall mount rack, 22" depth, 18 space
1	Middle Atlantic	FD-18	18SP Solid Frontdr, Univ.
1	Middle Atlantic	PD- 915R	15 AMP Horizontal Rackmount power distribution unit

Qty	Mfr.	Model / Part #	Description
1	Rack Hardware	13RU - 30RU	Misc Accessory rack hardware for 13RU - 30RU racks
1	Rack Hardware	13RU - 30RU	Misc Core rack hardware for 13RU - 30RU racks
Video			
2	Arlington	LV2LP	Low Profile Low Voltage Mounting Bracket 2 Gang
2	Comprehensive	DISP-DISP-15ST	DisplayPort Male To Male Cable 15ft
2	Comprehensive	HD- HD-15PROBLK	Pro AV/IT High Speed HDMI Cable with ProGrip, SureLength, CL3- Jet Black 15ft
1	Extron	DTP HDMI 4K 230 Rx	HDMI Twisted Pair Extender
2	Extron	DTP T DWP 4K 232 D-W	Two Input DTP Transmitter for DisplayPort and HDMI with Audio Embedding - Wallplate *White*
1	Extron	IN1808 IPCP MA 70	Pro control processor and integrated 100 watt class D power amplifier
1	Extron	PS 1215 C	12V, 1.5A, Captive Screw Connector Includes a ZipClip
1	Extron	ZipClip 100 - Single	ZIPCLIP 100 - Single Piece
1	Middle Atlantic	RSH4A2S SONY BDPS1700	Custom 2 RU Rack Shelf for a Sony BDPS1700
1	Sony	BDP-S1700	Sony Black 3D Blu-Ray Disc Player
Wire			
350	Belden	22-2C-PSH-WHT-EA	22 AWG, 1 pair, plenum, shielded intercom/paging/public address cable. per foot white
1	Belden	24-4P-P-L6-EN-WHT	CAT6+ (350MHz), 23 AWG, 4 pair, plenum-cmp, u/utp-unshielded. 1000' roll white
2	BTX	CD-MX915H	MaxBlox Clamshell Hood for MaxBlox CD-MX Connectors
1	BTX	CD-MX9F	MaxBlox DB9 Female to Terminal Block Connector
1	BTX	CD-MX9M	MaxBlox DB9 Male to Terminal Block Connector
1	Liberty AV Solutions	16-2C-P-WHT	Commercial grade general purpose 16 AWG 2 conductor plenum cable -1000'
1	Liberty AV Solutions	24-4P-L6ASH-WHT	Category 6A F/UTP EN series 23 AWG 4 pair shielded cable - 1000'
AR	Liberty AV Solutions	RG6-P-CATV-WHT-EA	RG6 CCS dual shielded coaxial plenum cable swept to 3.0 GHz
20	Platinum Tools	105101-EA	Cat6a RJ45 Boots – 1 Piece Packages: Black
20	Platinum Tools	106190-EA	RJ45 Cat6A 10Gig Shielded Connector

2.4 CAFETERIA

A. Provide products as listed or approved equals.

Qty	Mfr.	Model / Part #	Description
Assistive Listening			
1	Listen Technologies	LP-40-072-01	Intelligent DSP RF Receiver 6-Pack (72 MHz)
2	Listen Technologies	LR-4200-072-P1	Intelligent DSP RF receiver package 1 (72 MHz)
1	Listen Technologies	LT-800-072-P1	Stationary RF Transmitter Package 1 (72 MHz)
Audio			
4	Attero Tech	unD6IO	4x2 Multi-IO Dante Wall Plate Interface
1	Bose ControlSpace	EX-1280 Processor	Processor includes 12 mic/line analog inputs, 8 analog outputs, 8 AmpLink digital outputs, 64x64 Dante™ and a flexible, open architecture signal processing.
6	Bose	DM5C White	DesignMax DM5C Flush Ceiling Speaker - White
9	Bose	FreeSpace FS2P	Pendant model with a full-range 2.25-inch transducer, low frequency range down to 83 Hz, and sensitivity of 87 dB SPL / 1W @ 1m. - Black
1	Bose PowerSpace	P2600A	2 x 600-watt power amplifier for zone-expansion applications
2	Comprehensive	XLRP-XLRJ-50ST	Standard Series XLR Plug to Jack Audio Cable 50ft
2	Comprehensive	XLRP-XLRJ-6ST	Standard Series XLR Plug to Jack Audio Cable 6ft
1	Denon	Pro Bluetooth Antenna - PkG	[NB] - Included Bluetooth Audio Antenna for the Denon DN-200BR
1	Denon Pro	DN-200BR	Stereo bluetooth audio receiver
4	Shure	SB900A	Lithium-Ion Rechargeable Battery
2	Shure		Dual Docking Charger with Power Supply
1	Shure	SM58S	Cardioid Dynamic, On-Off Switch
1	Shure	SM58	Cardioid Dynamic
2	Shure	ULXD1	Digital Wireless Bodypack Transmitter with Miniature 4-Pin Connector
2	Shure	ULXD2/SM58	Microphone Handheld Wireless Transmitter
1	Shure	ULXD4D	Dual digital wireless receiver with internal power supply, 1/2 wave antenna and rack mounting hardware
2	Shure	WL185	Wireless premium condenser lavalier mics for speech applications.

Qty	Mfr.	Model / Part #	Description
1	Tascam	IF-DA2	Dante interface card for Solid State Recorders SS-R250N/SS-CDR250N. Connection with 2 inputs and 2 outputs by mounting the IF-DA2 to the SS-R250N/SS-CDR250N for a Dante system.
1	Tascam	SS-CDR250N	Two-channel recorder/player for network applications with a variety of remote control options.
Cables and Connectors			
2	Comprehensive	CAT6-7PROBLK	Pro AV/IT Cat6 Cable, RJ45 Male to RJ45 Male Heavy Duty Patch Cable - Black 7ft - 550 Mhz
3	Comprehensive	HD18G-12PROBLK	Pro AV/IT Certified 18Gb 4K High Speed HDMI Cable with ProGrip 12ft Black
1	Comprehensive	MHD18G-3PROBLK	MicroFlex Pro AV/IT Certified 4K60 18G High Speed HDMI Cable with ProGrip Jet Black 3ft
1	Comprehensive	MHD18G-6PROBLK	MicroFlex Pro AV/IT Certified 4K60 18G
Control			
1	Extron	SMK 2 - White	Surface Mount Kit for TLP Pro 725M and TLS 725M - White
1	Extron	TLP Pro 725M - White	7" Wall Mount Touchlink Pro Touchpanel - White
1	Honeywell	CG511A	Touch Panel Security Cover
1	Pakedge	MS-1212	Pakedge® MS Series Layer 3 Managed Switch with OvrC 12 1G PoE+, 190W, 2 10G SFP+
Display			
1	Chief		Pipe and flange for projector
1	Chief	VCTUW	Projector Mount
1	Panasonic	PT- RZ870*	WUXGA 1920 X 1200 8500 LMNS DLP LASER PROJECTOR W LENS
Equipment Rack			
3	Liberty AV Solutions	Dante Wall Plate	RJ45/Dante Wall Plate
1	Middle Atlantic	DWR- 18-22	DWR sectional wall mount rack, 22" depth, 18 space
1	Middle Atlantic	FD-18	18SP Solid Frontdr, Univ.
1	Middle Atlantic	PD- 915R	15 AMP Horizontal Rackmount power distribution unit
1	Rack Hardware	13RU - 30RU	Misc Accessory rack hardware for 13RU - 30RU racks
1	Rack Hardware	13RU - 30RU Core	Misc Core rack hardware for 13RU - 30RU racks
Video			
3	Arlington	LV2LP	Low Profile Low Voltage Mounting Bracket 2 Gang

Qty	Mfr.	Model / Part #	Description
3	Comprehensive	DISP-DISP-15ST	DisplayPort Male To Male Cable 15ft
3	Comprehensive	HD- HD-15PROBLK	Pro AV/IT High Speed HDMI Cable with ProGrip, SureLength, CL3- Jet Black 15ft
2	Extron	DTP HDMI 4K 230 Rx	HDMI Twisted Pair Extender
3	Extron	DTP T DWP 4K 232 D-W	Two Input DTP Transmitter for Display-Port and HDMI with Audio Embedding - Wallplate *White*
1	Extron	IN1808 IPCP MA 70	Pro control processor and integrated 100 watt class D power amplifier
2	Extron	PS 1215 C	12V, 1.5A, Captive Screw Connector Includes a ZipClip
2	Extron	ZipClip 100 - Single	ZIPCLIP 100 - Single Piece
1	Middle Atlantic	RSH4A2S SONY BDPS1700	Custom 2 RU Rack Shelf for a Sony BDPS1700
1	Sony	BDP-S1700	Sony Black 3D Blu-Ray Disc Player
Wire			
350	Belden	22-2C-PSH-WHT-EA	22 AWG, 1 pair, plenum, shielded intercom/paging/public address cable. per foot white
1	Belden	24-4P-P-L6-EN-WHT	CAT6+ (350MHz), 23 AWG, 4 pair, plenum-cmp, u/utp-unshielded. 1000' roll white
2	BTX	CD-MX915H	MaxBlox Clamshell Hood for MaxBlox CD-MX Connectors
1	BTX	CD-MX9F	MaxBlox DB9 Female to Terminal Block Connector
1	BTX	CD-MX9M	MaxBlox DB9 Male to Terminal Block Connector
1	Liberty AV Solutions	16-2C-P-WHT	Commercial grade general purpose 16 AWG 2 conductor plenum cable -1000'
1	Liberty AV Solutions	24-4P-L6ASH-WHT	Category 6A F/UTP EN series 23 AWG 4 pair shielded cable - 1000'
AR	Liberty AV Solutions	RG6-P-CATV-WHT-EA	RG6 CCS dual shielded coaxial plenum cable swept to 3.0 GHz
20	Platinum Tools	105101-EA	Cat6a RJ45 Boots – 1 Piece Packages: Black
20	Platinum Tools	106190-EA	RJ45 Cat6A 10Gig Shielded Connector

2.5 WEIGHT ROOM

A. Provide products as listed or approved equals.

Qty	Manufacturer	Model	Description
1	Bose	S1 Pro System	Self-powered portable speaker, 62 Hz-17 kHz, 109 dB peak SPL, 120 x 50 dispersion pattern, 35mm pole mount.
1	Chief	CHF-PMSC	Security Cable Kit
1	Extron	ASA 111	Passive Audio Summing Adapter with Stereo Mini Plug Input and Unbalanced Output
1	Pyle-Pro	PSTNDW15	Universal Standard 1-3/8" Insert pole-mount wall bracket, Tilt Angle Adjustment: 90°-30°, Swivel Angle Adjustment: ±30°, Weight Capacity: 80 lbs.
AR			Cabling to interface the Bose S1 Pro System to the Digital Flat Panel to be provided by the Owner under separate contract

2.6 FITNESS ROOM

A. Provide products as listed or approved equals.

Qty	Manufacturer	Model	Description
1	Bose	S1 Pro System	Self-powered portable speaker, 62 Hz-17 kHz, 109 dB peak SPL, 120 x 50 dispersion pattern, 35mm pole mount.
1	Chief	CHF-PMSC	Security Cable Kit
1	Extron	ASA 111	Passive Audio Summing Adapter with Stereo Mini Plug Input and Unbalanced Output
1	Pyle-Pro	PSTNDW15	Universal Standard 1-3/8" Insert pole-mount wall bracket, Tilt Angle Adjustment: 90°-30°, Swivel Angle Adjustment: ±30°, Weight Capacity: 80 lbs.
AR			Cabling to interface the Bose S1 Pro System to the Digital Flat Panel to be provided by the Owner under separate contract

2.7 BONDING & GROUNDING JUMPER CABLE

A. Provide bonding and grounding jumper cable.

1. Refer to Division 26, Section - Grounding and Bonding for Communication Systems.

2.8 CABLING

- Provide and terminate all cabling per manufacturers' recommendations for a completely operational system as specified.
- At all back box locations, cables shall have a minimum 18" service loop coiled in backbox.
- All cables shall be individually home-run.

- D. Microphone Cable: Provide one pair #22 AWG-shielded, stranded for each microphone.
- E. Speaker Cable: Provide one pair #18 AWG-stranded from each speaker to applicable amplifier.
 - 1. All cables shall be listed and labeled for environmental air plenums where cable is indicated in plenum spaces and is not indicated to be in raceway. Comply with requirements in Division 16 Section "Communications Horizontal Cabling."

2.9 SYSTEM INTERFACES

A. Public Address Interface

- 1. Mute Local Sound System broadcast during Public Address Announcements. Using the cable being provided between the public address system and the local sound system, properly interface this cable to the Local Sound System, and coordinate with the Public Address System Contractor the type of signaling you require. Provide all hardware/programming required at each system so when a public address announcement is made, the audio being broadcast by the local sound system will be muted during the duration of the public address all-call announcement. Once the public address announcement has ended, automatically return the local sound system to normal operations. Provide one for each local sound system specified.
- 2. The public address system Contractor shall provide a 10dB balanced-audio, line-level output from the public address system to each local sound system rack/cabinet/amplifier for interface.
- 3. Public Address system Contractor shall provide all cabling between these systems and provide interface to the public address system.
- 4. Local sound system Contractor shall interface cabling to the local sound systems to be used for muting of local sound systems audio during public address announcements.
- 5. All cables shall be individually home-run

B. Fire Alarm Interface

- 1. Mute Local Sound System broadcast during a Fire Alarm. Using the cable being provided between the Fire Alarm system and the local sound system, properly interface this cable to the Local Sound System, and coordinate with the Fire Alarm System Contractor the type of signaling you require. Provide all hardware/programming required at each system so when a Fire Alarm announcement is made, the audio being broadcast by the local sound system will be muted during the duration of the alarm. Once the alarm has ended, automatically return the local sound system to normal operations. Provide one for each local sound system specified.
- 2. The fire alarm system contractor shall provide a 10dB balanced-audio, line-level output from the fire alarm system to each local sound system rack/cabinet/amplifier for interface.
- 3. Fire Alarm Contractor shall provide all cabling between these systems.
- 4. Local sound system Contractor shall interface cabling to the local sound systems to be used for muting of local sound systems audio during fire alarms.
- 5. All cables shall be individually home-run.

2.10 COMPONENT MOUNTING RACKS

- A. Configuration: Comply with CEA-310-E. Factory-fabricated units designed for interchangeable mounting, forced or convection air cooling, wiring connection, and enclosure of standard 19-inch relay rack modules.
- B. Mounting Provisions: Equipped for wall mounting.

- C. Cabinet: Factory-finished steel with component mounting rails and prewired plug strips for component power connections. Full front and rear doors with continuous hinges, handles, and cylindrical keyed locks.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Speaker Assemblies: Suspend with chains from building structure above ceilings so bottom of assembly is 6 to 8 inches above upper plane of finished ceiling material. Use eyebolts on speaker assemblies for attachment. Suspend independently of supports for components of other building systems.
- B. Install seismic restraints on speakers. Comply with requirements for seismic-restraint devices specified in Division 16 Section "Vibration and Seismic Controls for Electrical Systems."
- C. Speaker Connections: For two- or three-channel systems, connect speaker assemblies alternatively so masking sound is redundant throughout zones of coverage.
- D. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and unless otherwise indicated.
 - 1. Except raceways are not required in accessible indoor ceiling spaces and attics.
 - 2. Except raceways are not required in hollow gypsum board partitions.
 - 3. Conceal raceways and wiring except in unfinished spaces.
- E. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Comply with requirements specified in Division 16 Section "Communications Horizontal Cabling" for cable trays
 - 3. Comply with requirements for raceways and boxes specified in Division 16 Section "Raceways and Boxes."
 - 4. Comply with requirements in Division 16 Section "Communication Horizontal Cabling."
- F. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
- G. Exposed Cable: Install parallel to building lines, follow surface contours, and support as recommended by manufacturer.
- H. Impedance Matching: For system components, including connecting cable, provide end-to-end level and impedance-matched signal paths. Use matching networks and balancing devices at connections where necessary to avoid mismatches.
- I. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.2 GROUNDING

- A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.

- C. Install grounding electrodes as specified in Division 16 Section "Grounding and Bonding."

3.3 IDENTIFICATION

- A. Use color-coded conductors and apply wire and cable marking tape to designate wires and cables so media are identified in coordination with system wiring diagrams. Comply with requirements for identification specified in Division 16 Section "Electrical Identification."
- B. Label speaker assemblies as to channel, zone, and address.

3.4 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electronic safety and security installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."
- B. Repair any disturbed fireproof spray material resulting from this work of this Section.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Programming
 - 1. DSP: The Contractor shall program all systems as per the owner's requirements.
 - 2. Pre-sets shall be marked with each configuration.
 - 3. Remote Control: The Contractor shall program the wall mounted remote control units to control all functions of the mixer/player/amp units
- D. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- E. Testing:
 - 1. Perform the following field tests and inspections, and prepare test reports:
 - a. Operational Test: After installing public address and music equipment and after electrical circuitry has been energized, test for compliance with requirements.
 - b. Operational Test: Perform tests that include originating program and page messages at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.
 - c. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:
 - 1) Disconnect microphone at connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Replace all other

- microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure signal-to-noise ratio.
 - 2) Repeat test for each separately controlled zone of loudspeakers.
 - 3) Minimum acceptance ratio is 50 dB.
 - d. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.
 - e. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB. In addition, the levels between locations in the same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.
 - f. Power Output Test: Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.
 - g. Signal Ground Test: Measure and report ground resistance at public address equipment signal ground. Comply with testing requirements specified in Division 16 Section "Grounding and Bonding."
2. Retesting: Correct deficiencies, revising tap settings of speaker-line matching transformers where necessary to optimize volume and uniformity of sound levels, and retest. Prepare a written record of tests.
- F. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.
- 3.6 TRAINING
- A. Engage a factory-authorized service representative to train Owner's facility personnel to adjust, operate, and maintain the local sound and video presentation systems.
 - B. Training shall include a minimum of two sessions for each system arranged with the owner at least one week prior to the training date. Training manuals shall be provided for each participant with one additional copy for archiving and storage at the site. Duration of training sessions shall be a minimum of two hours each.
 - C. Training sessions by either the manufacturer or an authorized manufacturer's representative shall be video recorded for all applicable features, functions, programming and operations for Owner's future reference.
 - D. General project information and review shall be by the General Foreman or Superintendent of the Trade.
 - E. As a minimum, training sessions shall consist of the following:
 - 1. Startup and Shutdown procedures for each system.
 - 2. Equipment settings for each system.
 - 3. General operation of each system.
 - 4. Review of optimal settings for various venues.
 - 5. Hands on training on all system hardware and features.

6. Basic troubleshooting techniques.

- F. Provide a troubleshooting guide to help identify the source of typical system problems.
- G. During the instruction period the Operating and Maintenance Manual shall be used and explained.
- H. The Operating and Maintenance Manual material shall be bound in 3-ring binders and indexed. On the edge of the binder provide a clear see-through plastic holder with a typed card indicating the Project name, the Owner's name, the installer's name and the Volume number (e.g., Vol. No. 1 of 2).
- I. Provide name, address, and telephone number of the manufacturer's representative and service company for all items supplied, so that the source of replacement parts and service can be readily obtained.
- J. Include copies of manufacturer's and installer's warranties and maintenance contracts, and performance bonds properly executed and signed by an authorized representative.
- K. Include copies of all test reports and certifications.

3.7 ACCEPTANCE DEMONSTRATION

- A. Final Acceptance Testing and Training: Demonstrations shall be in addition to necessary testing and training sessions.
 - 1. Provide a minimum of ten days' notice of acceptance test performance and training schedule. Schedule tests and training after pretesting has been successfully completed.
 - 2. Provide Operations Manuals to all participants.
 - 3. Obtain owner sign-off for training and submit as part of Closeout documentation.
- B. Recording Control Settings and System Adjustments: Record final control settings and programming and include reports in Operation and Maintenance Manual for the owner.

3.8 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions, or for additional training.
 - 1. Provide up to six visits to Project for this purpose.

3.9 SYSTEM DOCUMENTATION

- A. Label all equipment as herein specified.
- B. Provide all documentation for review ten business days before the substantial completion date for each construction phase.
- C. Provide documentation of test results in hard copy format for every cable segment and link shall be provided in 3-ring binders.
- D. Provide test results in electronic format along with testing report viewing software.

- E. Documentation for each test shall include measured values as well as whether or not the test passed.
- F. Provide "Record" drawings indicating location of all equipment, including but not limited to the following.
 - 1. Provide one-line diagrams for the Audiovisual systems as installed.
 - a. Include signal flow and functional diagrams
 - b. Include as-built diagram for cabling and connections
 - c. Include diagram of equipment arrangement in control racks
 - 2. Provide "As-built" Drawings for review with at least the following information.
 - a. All equipment and speaker locations identified.
 - b. Riser diagrams shall include one-line diagrams for cabling and speaker loops.
 - c. Floor diagrams shall include horizontal cabling pathways including penetrations and fire stopping
- G. Record Control Settings and System Adjustments: Document all final control settings and programming for each system, and turn over documentation to the Owner.
 - 1. Provide photos or facsimiles of front panel control knob settings for the Owner.
 - 2. Provide documentation on all programming and settings.

3.10 CLEANING UP

- A. Upon completion of all work and testing, thoroughly inspect all exposed portions of the installation and completely remove all exposed labels, markings, and foreign material.
- B. The interior of all boxes and cabinets shall be left clean; exposed surfaces shall be cleaned and plated surfaces polished.
- C. Repair damage to finished surfaces resulting from work under this Section.
- D. Remove material and equipment from areas of work and storage areas.
- E. All equipment shall be clean from dirt, dust, and fingerprints prior to final acceptance.
- F. Touch up all damaged pre-finished equipment using materials and methods recommended by the Manufacturer.

3.11 PROJECT CLOSEOUT

- A. Provide close-out submittals as required herein and in SECTION 01 78 00 – CLOSEOUT SUBMITTALS, including the following close out submittals.
 - 1. Operation and Maintenance Manuals
 - 2. Record Drawings with "as-built" corrections
 - 3. All Test Reports
 - 4. All Warranties
 - 5. Copies of video recordings of training sessions
 - 6. Copies of all sign-off and signed delivery sheets
 - 7. Documentation of Loose Equipment locations

8. Extra Materials.

- B. Provide copies of written delivery receipts of materials and/or equipment. Receipts shall specifically detail what was delivered (description, quantity, and specification section) and shall be dated and signed by delivery firm and by an Owner's representative.
- C. Provide copies of all signed training and acceptance documentation.

END OF SECTION

SECTION 27 51 15
PUBLIC ADDRESS SYSTEM
(Trade Sub-Sub-Bid Required as part of Section 26 00 00)

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SECTION 27 51 15
PUBLIC ADDRESS SYSTEM
(Trade Sub-Sub-Bid Required as part of Section 26 00 00)

PART 1 – GENERAL

1.1 TRADE SUB-BID REQUIREMENTS

- A. The Procurement and Contracting Requirements as listed in the Table of Contents, and applicable parts of Division 01 - General Requirements, shall be included in and made a part of this Section.

1.2 TRADE BID REQUIREMENTS

- A. Trade Contractor on this Project are required by law to provide Payment and Performance Bonds for the full value of his Trade Contract. Trade Contractor must include the full cost of the required Payment and Performance Bonds in the Bid price submitted to complete the Work of this Section. Trade Bids will only be accepted from Trade Contractors pre-qualified by the Awarding Authority.
- B. All Trade-Bids shall be submitted on the Trade Contractor Bid Form, included in the Specifications, in accordance with requirements of Chapter 149A of the Massachusetts General Laws, as amended.
- C. The attention of Trade Bidders is directed to Instructions to Bidders and Paragraph E of the Trade Contractor Bid Form. Trade-Bids shall be filed with the Awarding Authority in accordance with requirements stipulated therein.

1.3 RELATED DOCUMENTS

- A. All the Contract Documents, including Drawings, General Conditions, Supplementary Conditions, and all Sections of Division 01 - General Requirements, apply to the Work of this Section.
- B. The Trade Contractor for this Section shall examine all Drawings and all Sections of the Specification for requirements therein that may affect the Work of this Section, not just those Drawings and Specifications particular to the Work of this Section. The Work of this Section is shown primarily on the following listed Drawings:
 - 1. Architectural, "A" Drawings
 - 2. Electrical "E" series drawings
 - 3. Technology and Security drawings: T0-0-1 through T3-1
- C. The listing of the Contract Drawings above shall not limit responsibility to determine full extent of work of this Section as required by all Contract Drawings noted on the Contract Drawings-Title Sheet Drawing List, the Project Manual, and Addenda

1.4 SUMMARY

- A. The work under this Section includes the provision of material, labor, equipment, and supplies, and the performance of operations to provide a complete working Public Address and Intercom System as indicated on the Drawings and details, and as specified herein. Where the Drawings, Specifications, Codes, Regulations, Laws, or the requirements of the local Authority conflict, provide the higher quality and higher quantity indicated or required and follow the strictest requirement. In general, the work includes, but is not limited to, the following:

1. Public Address System Headend Enclosure/Cabinet.
 2. Preamplifiers.
 3. Power amplifiers.
 4. Transfer to standby amplifier.
 5. Power Supplies.
 6. Microphones.
 7. Volume limiter/compressors.
 8. Control console.
 9. Equipment cabinet.
 10. Equipment rack.
 11. Paging adapters for Telephone and VHF Radio interfaces.
 12. Tone generator.
 13. Monitor panel.
 14. Loudspeakers.
 15. Volume Control outlets.
 16. Noise-operated gain controllers.
 17. Battery Backup for System Programming.
 18. Program Distribution System.
 19. Administrative Intercom LCD Display Console.
 20. Interface to Local Sound Systems.
 21. Interface to Master Clock.
 22. Interface to Voice/Telephone system.
 23. Interface to Active Shooter/Duress Alert System
 24. Interface to VHF Radio system.
 25. Interface to Fire Alarm System.
 26. UPS Battery Backup System.
 27. Wiring.
 28. Training
- B. Nameplates, Labels, and Tags.
- C. Cabling system identification products.
- D. Terminations.
- E. UL 497 Primary and UL 497A secondary line lightning and Surge Protection:
1. Surge and Lightning Protection for cabling run through underground PVC conduits.
- F. Protection of new and existing work.
- G. Record Drawings and Documentation.
- H. Staging.
- I. Access panels and doors.
- J. Coordination with Owner.
1. Coordinate with the Owner to obtain zoning requirements.
- K. Coordination with manufacturers and other trades.
1. Coordinate work with that of other trades affecting or affected by work of this Section.
Cooperate with such trades to assure the steady progress of work under the Contract.

- L. Testing and Certification of cabling.
- M. Operation and Maintenance Instructions and Manuals for the Section's work.
- N. Documentation: As-built Drawings and Test Reports.
- O. Provide and maintain in safe adequate condition staging and scaffolding required for the proper execution of the work of this Section.
- P. The Subcontractor shall remove and re-install ceiling tiles necessary for the work of this section.
 - 1. Replace ceiling tiles damaged as a result of the work of this section at no cost to the owner.
- Q. Removal of trash from site and cleanup of areas of work under this SECTION.
 - 1. The Subcontractor shall perform daily clean-up of areas of work under this section and remove trash from the site.
- R. Coordinate with the Architect's reflected ceiling lighting plan for proper location of speakers installed in suspended ceilings.

1.5 RELATED SECTIONS

- A. Related Sections include the following:
 - Section 26 00 00 "Electrical"
 - Section 26 05 26 "Grounding and Bonding"
 - Section 26 05 33 "Raceways and Boxes"
 - Section 27 41 01 "Local Sound Systems"
 - Section 27 51 20 "Classroom Speech Reinforcement Systems"
 - Section 27 53 13 "Clock System"

1.6 SUBMITTALS

- A. Submit under the provisions of Division 01 Section "Submittal Procedures".
- B. LEED Submittal – refer to Division 01 Sustainable Design Requirements.
 - 1. LEED submittals are in addition to other submittals. If submitted item is identical to that submitted to comply with other requirements, submit duplicate copies as a separate submittal to verify compliance with indicated LEED requirements.
 - 2. Project Materials Cost Data: Provide statement indicating total cost for materials used for Project.
 - 3. LEED Action Plans: Provide preliminary submittals indicating how the following requirements will be met:
 - a. Construction Waste Management: in compliance with Division 01 Section "Construction Waste Management."
 - b. List of proposed materials with recycled content: Manufacturers certification of recycled content indicating percentage by weight of both pre-consumer and post-consumer recycled content.
 - c. Local/Regional Materials:

- 1.) Sourcing location(s): Indicate location of extraction, harvesting, and recovery of raw materials used in the products manufacturing; indicate distance between extraction, harvesting, and recovery and the project site.
 - 2.) Manufacturing location(s): Indicate location of manufacturing facility; include distance between manufacturing facility and the project site.
- C. Submit within (30) days of Contract award and prior to installation of any materials or equipment complete shop drawings, product data, schedule of values, and qualification documentation to the Architect for approval review.
1. SUBMIT ALL ITEMS IN A SPECIFICATION SECTION AT THE SAME TIME An incomplete submittal will be held until a complete submittal is accumulated, or may be rejected without further review and returned to the applicable parties. .
- D. Provide a Bill of Materials that clearly identifies the information requested herein for each and every item submitted. Include the Specification Paragraphs pertaining to each item submitted The Bill of Materials shall include the following "headings" in the order indicated from left-to-right on the Bill of Materials Index/Equipment List:
1. Item Number
 2. Manufacturer's "Name" for each item
 3. Manufacturer's "Model Number" for each item
 4. Manufacturer's "Description" of each item
 5. "Specification Section Number", reference specification section number/location for the item submitted.
 - a. Example of Specification Section number/location: 2.13, B., 7., c., 4), e), page number
 6. Bill of Material Header Example:

Item #.	Mfr. Name	Mfr. No.	Description	Spec Ref	Qty	Pg. No.
---------	-----------	----------	-------------	----------	-----	---------
 7. All Bill of Material items shall be listed in the Bill of Material Index / Equipment List, in the same order as they appear in the specification.
 8. On each and every data sheet, indicate the applicable part numbers(s) on the sheet(s) by one of the following methods:
 - a. Circling the applicable part number(s)
 - b. Putting an arrow next to the applicable part number(s)
 - c. Highlighting the applicable part number(s)
 9. Shop drawings shall include but not be limited to the following:
 - a. Built-in station arrangement.
 - b. Equipment cabinet arrangement.
 - c. One-line drawings.
 10. Include in the submittal:
 - a. Warranty information for all components, including a letter from manufacturers verifying the proposed cabling and materials are eligible for a 25-year manufacturer's warranty.
 - b. Qualification Data: For qualified Contractor.
 - c. Field quality-control reports.

d. Operation and Maintenance Data.

- E. If proposed equipment deviates from the Specifications or Drawings, indicate in writing on Company letterhead those differences and provide sufficient data to justify acceptance. FAILURE TO INDICATE DEVIATIONS OR SUBSTITUTIONS IMPLIES FULL COMPLIANCE WITH DRAWINGS AND SPECIFICATIONS.
- F. It is intended that Submittal be complete and accurate at the first submission.
 - 1. Submit all required Submittal information at one time.
 - 2. An incomplete Submittal shall be rejected in its entirety.
- G. A minimum period of (15) working days, exclusive of transmittal time, will be required each time for review of a Submittal or Resubmittal. An additional (20) working days, exclusive of transmittal time, will be required for reviewing substitute materials or manufacturer. The review time period shall be considered by the Contractor when scheduling the work.
- H. No equipment or material shall be used, furnished, or installed unless previously reviewed and accepted by the Architect.
- I. Reviewed submittals on substitute equipment shall only allow the Contractor to proceed with installation. The substitution shall not be considered equal until such time as the Owner and Owner's Representative have completely accepted the installation. All costs for removal, relocation, or replacement of said Substitution shall be at the risk of the Contractor.
- J. Regardless of any information included in the submittal submitted for review, the requirements of the Drawings and Specifications shall not be superseded in any way by the review. Review by the Architect does not relieve responsibility for submittal errors or from meeting the requirements of the Contract Documents.

1.7 SCHEDULE OF VALUES

- A. As part of the Submittal, provide a Schedule of Values with Unit Pricing to the Architect for approval review.
- B. Schedule of Values
 - 1. Provide a schedule of values to be approved by Owner's representative, itemizing costs by construction phase for each technology system for labor and materials, with additional breakdowns for rough and finish work by construction phases, by system.
 - 2. The schedule of values shall be submitted for review and acceptance prior to the paying of any invoice.
 - 3. The schedule of values shall accurately reflect the actual costs for each category, including allocation for overhead and profit.
 - a. As a minimum, provide the following breakdown, by phase where applicable, as indicated:
 - 1.) Each major piece of equipment
 - 2.) Other equipment by category
 - 3.) Material and labor for each item.
 - 4.) Equipment installation by category and each major piece of equipment.
 - a) Roughing work.

b) Finish work.

- 5.) Bond
- 6.) Testing.
- 7.) Owner training.
- 8.) Operation and Maintenance Manuals.
- 9.) Record drawings.

1.02 REGULATORY REFERENCES

- A. Comply with applicable requirements of the following standards and those others referenced in their Section.
- B. All work and materials shall conform in every detail to the rules and requirements of the National Fire Protection Association, the local Electrical Code, and present manufacturing standards.
- C. All materials shall be UL Listed and shall be marked as such. If UL has no published standards for a particular item, then other national independent testing standards shall apply and such items shall bear those labels. Where UL has an applicable system listing and label, the entire system shall be so labeled
- D. All materials shall be ETL Verified (not just tested) to be Category 6e component and channel compliant.
- E. Materials and equipment shall be manufactured, installed, and certified as specified in the latest editions of applicable publications, standards, rulings, and determinations

1.03 QUALITY ASSURANCE

- A. Subcontractor Qualifications: Manufacturer's authorized representative who is trained and approved for installation of equipment required for the work of this Section.
 - 1. The Subcontractor (Firm and Employees) shall be experienced in the operations they are engaged to perform.
 - 2. The Subcontractor must provide documentation as part of the submittal process that they themselves are trained and authorized for installation of products specified.
 - 3. The Subcontractor must customarily furnish the size, scope, and nature of this Section and must be an authorized manufacturer's representative, certified (if certification programs exist with such manufacture), experienced, and qualified to provide, install, program, troubleshoot, train, warrant, and service the systems in this section in their entirety.
 - 4. Provide documentation as part of the submittal process that the Subcontractor is authorized by the manufacturer(s) for products to be installed as part of this Section, and are experienced and qualified to provide, install, program, troubleshoot, train, warrant, and service systems and products specified in this Section.
 - 5. Provide documentation as part of the submittal process that the Subcontractor holds recent, up-to-date licenses and training certificates for the equipment to be installed.
 - 6. The Subcontractor must provide as part of the submittal process a list of at least five (5) projects of similar size, scope, and nature.
 - a. Provide the following information for each project:
 - 1) Name of Project
 - 2) Address
 - 3) Contact Person, Title, and Telephone Number

- B. Testing Agency Qualifications: Qualified agency, with the experience and capability to conduct testing indicated.
- C. Comply with current TIA/EIA Building Telecommunications Wiring Standards and BICSI Telecommunications Distribution Methods and Standards.
- D. Comply with NFPA 70.

1.04 PERFORMANCE REQUIREMENTS

- A. The Installer shall comply and reference the latest editions of the following standards including related addendum or TSB's not listed below:
 - 1. ANSI/TIA/EIA-526-7, Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
 - 2. ANSI/TIA/EIA-526-14-C, Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant
 - 3. ANSI/TIA/EIA-568-C.0, Generic Telecommunications Cabling for Customer Premises
 - 4. ANSI/TIA/EIA--568-C.1, Commercial Building Telecommunications Cabling Standard Part 1: General Requirements
 - 5. ANSI/TIA/EIA-568-C.2, Balanced Twisted-Pair Telecommunications Cabling and Components Standards
 - 6. ANSI/TIA/EIA-568-C.3, Optical Fiber Cabling Components Standard
 - 7. ANSI/TIA/EIA -569-D, Telecommunications Pathways and Spaces
 - 8. ANSI/TIA/EIA--598-D, Optical Fiber Cable Color Coding
 - 9. ANSI/TIA/EIA-606-B, Administration Standard for Commercial Telecommunications Infrastructure
 - 10. ANSI/TIA/EIA-607-B, Commercial Building Grounding and Bonding Requirements for Telecommunications
 - 11. ANSI/TIA/EIA 310D, Cabinets, Racks, Panels and Associated Equipment
 - 12. BICSI, TDMM, Telecommunications Distribution Methods Manual (TDMM)
 - 13. BICSI, Information Technology Systems Installation Methods Manual (ITSIMM)
 - 14. BICSI, Outside Plant Design Reference Manual (OSPDRM)
 - 15. BICSI, Electronic Safety and Security Design Reference Manual (ESSDRM)
 - 16. ANSI
 - 17. FCC Part 15 (addresses electromagnetic radiation).
 - 18. FCC Part 68 (connection of premises equipment and wiring to the network).NEC – National Electric Code (NEC)
 - 19. National Electrical Safety Code Handbook. (NESC)
 - 20. NFPA-70 – National Fire Protection Association (NFPA – 70)
 - 21. State and Local Building Codes.

1.05 DELIVERY, STORAGE, AND HANDLING:

- A. Do not deliver items to the site until specified submittals have been submitted to, and approved by, the Architect.
- B. Deliver materials in original packages, containers, or bundles bearing a brand name, or identification of manufacturer or supplier.
- C. Deliver, store, protect, and handle products in accordance with recommended practices listed in Manufacturer's Installation and Maintenance Manuals.

- D. Protect materials from damage due to moisture, direct sunlight, excessive temperatures, surface contamination, corrosion, and damage from construction operations and other causes.

1.06 WARRANTY

- A. Provide a warranty for two years against defects in material and workmanship on components, equipment, software, systems, cabling, and installation/setup. Warranty shall start at time of substantial completion or routine use, whichever comes first. Warranty shall include materials, equipment, and work furnished or installed under this Section. failure due to defective material, equipment, installation, or workmanship that may develop shall be corrected at no expense to the Owner, including materials, labor, travel, expenses, system diagnostics, and damage to areas, materials, and other systems resulting from such failures.
- B. Additionally, all manufacturer supplied products must be covered by three year (parts only) limited warranty from the date of acceptance. The warranty period shall begin on the date of acceptance by the Owner.
- C. Manufacturers shall provide replacement warranties for material and equipment furnished under this Section. Such warranties shall be in addition to and not in lieu of, liabilities that the Manufacturer and the Installer may have by law or by provisions of the Contract Documents.
 - 1. Include copies of warranties, maintenance contracts, and training contracts or performance bonds in the Operation and Maintenance Manuals.

1.07 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - Administrative Intercom LCD Display Console: Provide – 1
 - Microphone: Provide – 1
 - Desk Stand: Provide – 1

1.08 SEISMIC REQUIREMENTS

- A. Equipment and work shall meet the restraint requirements for a Seismic Zone - 2 location, including installation and connections of material and equipment to the building structure.

PART 3 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following, or approved equal.
1. Bogen Communications, Inc.

Quantum Multicom IP Public Address and Intercom Systems, and other components required for a completely operational system as specified.
 2. Telecor

Public Address and Intercom Systems, and other components required for a completely operational system as specified.
 3. TOA

Public Address and Intercom Systems, and other components required for a completely operational system as specified.
- B. General:
1. Provide equipment, accessories, and materials in accordance with these specifications and related documents to provide a complete and operating Public Address and Intercom System.

2.2 SYSTEM DESCRIPTION

- A. The Public Address and Intercom System shall provide the school with state of the art technology for Sound Systems specified. The processor card shall have a built-in web server so the users can log in to the web server via a compatible web browser and use a graphical interface for full system programming day-to-day system operation.
- B. The system shall also provide telephonic features as specified once properly interfaced to a telephone system. The system shall be easy to learn and operate. standard system programming shall be user-friendly to allow the system administrator the ability to easily re-program station features.
1. Provide complete and satisfactorily operating, Public Address and Intercom System as described herein, using materials and equipment of types, sizes, ratings, and performances as indicated. Use materials and equipment that comply with referenced standards and manufacturers' standard design and construction, in accordance with published product information. Coordinate the features of materials and equipment so they form an integrated system, with components and interconnections matched for optimum performance of specified functions.
 2. Features offered by this system shall be implemented and controlled by software programs that can be changed and expanded as needs evolve.
 3. Interface the Public Address and Intercom System's battery backup power cord to an outlet in the MDF/MCER that is on the Emergency Generator.
 4. System shall use 25-volt public address and intercom speakers, systems that use 45-ohm speakers shall not be acceptable.

2.3 FUNCTIONAL DESCRIPTION OF SYSTEM

- A. Descriptions in this article are examples only; revise to indicate actual design intent.
- B. System Functions:
 - 1. Selectively connect zones to available signal channels.
 - 2. Selectively control sound from microphone outlets and other inputs.
 - 3. "All-call" feature shall connect the all-call sound signal simultaneously to zones regardless of zone or channel switch settings.
 - 4. Telephone paging adapter shall allow paging by dialing an extension from local telephone instrument and speaking into the telephone.
 - 5. Produce a program-signal tone that is amplified and sounded overall speakers, overriding signals currently being distributed.
 - 6. Reproduce high-quality sound that is free of noise and distortion at loudspeakers at times during equipment operation including standby mode with inputs off; output free of non-uniform coverage of amplified sound.

2.4 SYSTEM REQUIREMENTS

- A. The system shall lend itself to expansion by the simple addition of modules.
- B. Two-way communication between telephone and classroom speaker.
- C. Eight separate paging/class pass zones shall be provided; each location shall be programmed in software to belong to combination of software zones.
- D. Amplified two-way voice communication shall be available from dial phone in the system, through classroom speaker in the system.
 - 1. This shall allow hands-free communication to classroom loudspeaker unit. A warning tone shall sound and continue to sound at regular intervals when speaker monitoring is active.
 - 2. Central Switching Network System Administration, the Public Address and Intercom Systems shall provide the following capabilities:
 - a. Centralized attendant answering.
 - b. A minimum of 216 sound/speaker stations for present and future system expansion capabilities.
 - c. Storage of diagnostic results and other system messages. These may be printed out upon request via local or remote access.
 - d. Main control unit to store information and give reports on features, restrictions and hunting patterns upon request either on-site or remotely.
 - e. Automatic sounding of a warning tone signal over loudspeaker selected for two-way communications to alert the station attendant (classroom teachers) to the call and prevent unauthorized monitoring.
 - f. Access to single classroom loudspeaker unit, zone loudspeaker unit, or loudspeaker units. The warning tone signal shall sound as soon as the station is selected and shall be automatically repeated at regular intervals for the duration of the call if the voice circuit is not activated.
 - g. Instantaneous distribution of emergency announcements by single-button access, simultaneously to locations equipped with speakers.
 - 1) Emergency announcements originating from assigned administrative telephone shall have priority over regular system functions.

3. Distribution, by single-button access, of four distinct alarm signals to areas equipped with speakers.
4. Assignment of speaker locations within one or more of the sixteen zones for zone paging or time signal reception; this assignment is to be programmable. Systems without this feature will not be acceptable.
5. Origination of both emergency call-ins and nurse emergency call-ins from staff location.
6. Call-ins originating from staff location can be programmed for assignment to up to 12 locations simultaneously.
7. Review of call-ins stored in memory, in groups of four, in the order received.
8. Answering of calls registered in the digital read-out display merely by pressing a single response button. This capability shall not prevent other calls from being placed or answered by dialing their numbers.
9. Multiple loudspeaker or telephone conversations to take place and not prevent announcements, educational, or music programs from being distributed to other areas of the building.
10. Broadcasting emergency instructions to the entire school. This capability shall be restricted to certain authorized telephones.
11. Single-button access to allow page announcements into speaker zones without interrupting others performing simultaneous functions.
12. Provide Public Address and Intercom System Programming/Diagnostics Software which shall provide the following capabilities/programming/diagnostics from a single software program accessed and controlled from an owner-supplied desktop computer or workstation.
 - a. Provide and load Public Address and Intercom System Programming/Diagnostics Software onto an owner-supplied desktop computer or workstation. Provide proper interface of the computer to the public address and intercom system.

2.5 DEVICES

- A. Type IMS - Provide Administrative Intercom LCD Display Console indicated on the drawings. Also, provide one unit at the Public Address, Intercom Systems head-end, unit shall be mounted on the outside of the rack/cabinet, which shall provide functions as scheduled below:
 1. The associated digital display shall provide a 16-character display of numerals or letters.
 2. The unit shall be a multi-button console with industry-standard Twelve-(12) button DTMF matrix keys.
 3. Provide a built-in soft tone ringer with volume control.
 4. Instrument shall include "Last Number Redial" key to permit a user to automatically redial most recently dialed number.
 5. Provide single button activation of the following features.
 - a. All-call paging button.
 - b. Zone page button
 - c. Class change signal button
 - d. Emergency evacuation signal button
 - e. Program (Music) distribution button.

2.6 PROGRAM DISTRIBUTION SYSTEM

- A. System shall provide the maximum capacity of function as stated herein.
- B. School shall have the ability to provide selective programming.

- C. The school shall be provided with a minimum of two (2) program channels, eight-time channels, sixteen zone-page channels, and multiple linkages for telecommunications.
- D. Time zones may be easily selected and easily accessed by designated administrative control units. A means of programming loudspeakers for the separate zone functions shall allow for easily arranging and rearranging zones. Simultaneous administrative control unit functions and channel programming shall in no way cause system interference.
- E. Capability for assigning speaker locations within one or more of the zones for zone-paging or time signal reception; this assignment is to be a programmable function. Systems without this feature will not be acceptable.
- F. Time signal tones shall be generated throughout the zone selected for time signaling over programmed loudspeakers on a manual or automatic basis.
- G. Emergency tones shall be distributed from designated administrative control units.
- H. All power amplifiers shall utilize 25-volt industry-standard outputs to public address and intercom speakers in the system, and shall meet specifications exactly as specified herein, including power capacity and count. Power amplifiers shall also provide a minimum of 25-volt, half-watt power to speaker locations, 15 watts of power to horn-type speaker locations, plus 15% spare wattage for future expansion.
- I. The system shall be equipped with one rack-mounted AM/FM tuner, one rack-mounted CD player, and one front-mounted monitor panel.
 - 1. A front-mounted monitor panel shall include a back-lit digital readout that displays the time; a monitor speaker that permits these audio programs to be monitored before they are transmitted to classrooms or other locations; and a four-position monitor switch offering the following selections: send program; send/monitor program; monitor program only, and "OFF" position.
- J. Roof-mounted Antenna:
 - 1. A dedicated roof-mounted, twin dipole, Omni-directional FM Antenna shall be provided. Two half-wave dipole elements mounted 90 degrees to one another on the antenna mast give this antenna an Omnidirectional reception pattern. The antenna shall be supplied with the following accessories: connector cable, an 18 in. boom, vertical mounting bracket, and horizontal mounting bracket. The Antenna shall be a Blonder Tongue FM Omni-Directional Antenna #BTY-2-FM, or approved equal.
 - 2. Provide an RG-6U coax cable between the roof-mounted antenna location and the AM/FM tuner location, terminated with "F" type connectors.
 - a. Antenna location shall be determined by Architect.
- K. Audio Program Distribution
 - 1. The system shall provide the capability to distribute program material (i.e., music, CD player, and radio broadcasts) to a room, multiple rooms, zone, or zones serviced by the system speakers.
 - 2. The system shall provide non-restrictive program distribution channels.
 - 3. The user shall cue a remotely located music source or select a radio station.
 - 4. From an Administrative LCD Intercom Display Console or a properly interfaced telephone, the user can select the room(s) or areas to which to distribute the program.

5. Systems that require manually operated switch-banks for distribution shall not be acceptable.

2.7 GENERAL EQUIPMENT AND MATERIAL REQUIREMENTS

- A. Compatibility of Components: Coordinate component features to form an integrated system. Match components and interconnections for optimum performance of specified functions.
- B. Equipment: Comply with UL 813. Equipment shall be modular, using solid-state components, and fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz.
- C. Equipment Mounting: Where rack, cabinet, or console mounting is indicated, equipment shall be designed to mount in a 19-inch housing complying with TIA/EIA-310-D.
- D. Weather-Resistant Equipment: Listed and labeled by a qualified testing agency for duty outdoors or in damp locations.

2.8 PREAMPLIFIERS

- A. Preamplifier: Separately mounted.
- B. Preamplifier: Integral to the power amplifier.
- C. Output Power: Plus 4 dB above 1 mW at matched power-amplifier load.
- D. Total Harmonic Distortion: Less than 1 percent.
- E. Frequency Response: Within plus or minus 2 dB from 20 to 20,000 Hz.
- F. Input Jacks: Minimum of two. One matched for the low-impedance microphone; the other matchable to the cassette deck, CD player, or radio tuner signals without external adapters.
- G. Minimum Noise Level: Minus 55 dB below-rated output.
- H. Controls: On-off, input levels, and master gain.

2.9 POWER AMPLIFIERS

- A. Mounting: Rack.
- B. Output Power: 70-V balanced line. 80 percent of the sum of wattage settings of connected for each station and speaker connected in an all-call mode of operation, plus an allowance for future stations.
- C. Total Harmonic Distortion: Less than 3 percent at rated power output from 50 to 12,000 Hz.
- D. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.
- E. Frequency Response: Within plus or minus 2 dB from 50 to 12,000 Hz.
- F. Output Regulation: Less than 2 dB from full to no load.

- G. Controls: On-off, input levels, and low-cut filter.
- H. Input Sensitivity: Matched to the preamplifier and to provide full-rated output with the sound-pressure level of less than 10 dynes/sq. cm impinging on speaker microphone or handset transmitter.

2.10 TRANSFER TO STANDBY AMPLIFIER

- A. Monitoring Circuit and Sensing Relay: Detect reduction in output of power amplifier of 40 percent or more and, in such event, transfer load and signal automatically to standby amplifier.

2.11 MICROPHONES

- A. Paging Microphone:
 - 1. Type: Dynamic, with cardioid polar characteristic.
 - 2. Impedance: 150 ohms.
 - 3. Frequency Response: Uniform, 50 to 14,000 Hz.
 - 4. Output Level: Minus 58 dB, minimum.
 - 5. Finish: Satin chrome.
 - 6. Cable: C25J.
- B. Mounting: Desk stand with integral-locking, press-to-talk switch.

2.12 VOLUME LIMITER/COMPRESSOR

- A. Minimum Performance Requirements:
 - 1. Frequency Response: 45 to 15,000 Hz, plus or minus 1 dB minimum.
 - 2. Signal Reduction Ratio: At least a 10:1 and 5:1 selectable capability.
 - 3. Distortion: 1 percent, maximum.
 - 4. Rated Output: Minimum of plus 14 dB.
 - 5. Inputs: Minimum of two inputs with variable front-panel gain controls and VU or decibel meter for input adjustment.
 - 6. Rack mounting.

2.13 EQUIPMENT CABINET

- A. Comply with TIA/EIA-310-D.
- B. House amplifiers and auxiliary equipment at each location.
- C. Cabinet Housing:
 - 1. Retain rear-locking doors in first subparagraph below if cabinet rear is accessible.
 - 2. Constructed of 0.0478 in. steel, minimum, with front- and rear-locking doors and standard TIA/EIA-310-D-compliant, 19 in. racks.
 - 3. Arranged for floor or wall mounting as indicated.
 - 4. Sized to house equipment indicated, plus spare capacity.
 - 5. Include 20 percent minimum spare capacity for future equipment in addition to space required for future cassette deck and CD player.

- D. Power Provisions: A single switch in the cabinet shall disconnect the cabinet power distribution system and electrical outlets, which shall be uniformly spaced to accommodate ac-power cords for each item of equipment.
- E. Ventilation: A low-noise fan for forced-air cabinet ventilation. Fan shall be equipped with a filtered input vent and shall be connected to operate from 105- to 130-V ac, 60 Hz; separately fused and switched; arranged to be powered when the main cabinet power switch is on.

2.14 TELEPHONE PAGING ADAPTER

- A. Adapters shall accept voice signals from telephone extension dialing access and automatically provide amplifier input and program override for preselected zones.
 - 1. Minimum Frequency Response: Flat, 200 to 2500 Hz.
 - 2. Impedance Matching: Adapter matches telephone line to public address equipment input.

2.15 TONE GENERATOR

- A. Generator shall provide clock and program interface with public address and mass notification system.
- B. Signals: Minimum of seven distinct, audible signal types including wail, warble, high/low, alarm, repeating and single-stroke chimes, and tone.
- C. Pitch Control: Chimes and tone.
- D. Volume Control: outputs.
- E. Activation-Switch Network: Establishes priority and hierarchy of output signals produced by different activation setups.

2.16 LOUDSPEAKERS

- A. Note: public address and intercom speakers shall be 2-way speakers for bi-directional intercom use.
- B. All speakers shall blend in with the surroundings of their location and are to be painted colors as selected by the architect by the Contractor. Coordinate colors for each location with the architect prior to beginning of work.
- C. Speakers: Public Address and Intercom Speakers (classrooms, offices, hallways, and common spaces) shall be 25-Volt, with line-matching transformer speakers.
 - 1. Systems that use 45 ohm speakers shall not be acceptable.
- D. Cone-Type Loudspeakers:
 - 1. Minimum Axial Sensitivity: 91 dB at one meter, with 1-W input.
 - 2. Frequency Response: Within plus or minus 3 dB from 50 to 15,000 Hz.
 - 3. Size: 8 in. with 1 in. voice coil and minimum 5-oz. ceramic magnet.
 - 4. Minimum Dispersion Angle: 100 degrees.
 - 5. Rated Output Level: 10 W.
 - 6. Matching Transformer: Full-power rated with four taps. Maximum insertion loss of 0.5 dB.

7. Surface-Mounting Units: Ceiling, wall, or pendant mounting, as indicated, in steel back boxes, acoustically dampened. Front face of at least 0.0478 in. steel and whole assembly rust proofed, and shop primed for field painting.
 8. Flush-Ceiling-Mounting Units: In steel back boxes, acoustically dampened. Metal ceiling grille with white baked enamel.
- E. Device in paragraph below is an example only; revise to suit Project requirements. Coordinate with Drawings.
- F. Horn-Type Loudspeakers, Lowell UNIHORN LUH-15T, or approved equal:
1. Type: Flush single-horn units, reentrant design, with minimum full-range power rating of 15 watts continuous.
 2. The re-entrant horn loudspeaker shall be a self-contained compression driver within an aluminum weather-resistant housing that can be installed into 4 in. Deep spaces.
 3. Frequency response shall be 740Hz-7.4kHz (+/-6dB).Dispersion Angle: 130 by 110 degrees.
 4. Sound pressure level shall be 105dB (1W1M) average, 116.8dB SPL (max) 15W/1M calculation based on power rating and measured sensitivity.
 5. Dispersion shall be 80 degrees @2000Hz (-6dB).
 6. The unit shall include a 70/25V transformer with taps selectable on front and rear of horn.
 7. The horn shall include a connected DC blocking capacitor (10uf NP) for supervised system applications and will ship ready for standard two-wire connection with cable exiting through a rear cable clamp.
 8. The housing shall be 7.1 in. dia. at its widest measure with an 8 in. dia. flat face.
 9. The assembly shall include an aluminum trim ring/grille that is 9.6in. dia. with no visible hardware and neutral grey finish.
 10. Units in Hazardous (Classified) Locations: Listed and labeled for the environment in which they are located.
- G. Lay-In Speaker Package by Penton, #LiS8T, or approved equal, for flush suspended-ceiling speaker applications.
1. Unit shall be a 1-piece assembly comprised of a damped high-compliance 8 in. loudspeaker, factory-mounted, 70.7/25-volt transformer, tile bridge, enclosure, and 1 ft. x 2 ft. grille. Speaker shall include a 10-watt, twin-cone speaker and transformer having power taps of 5, 2, 1, 0.5, and 0.25 watts. Output shall be 95 dB @ 1 watt, 1 meter. The frequency response shall be 60Hz-20 kHz.

2.17 NOISE-OPERATED GAIN CONTROLLER

- A. Gain controller shall be designed to continuously sense space noise level and automatically adjust the signal level to local speakers.
- B. Frequency Response: 20 to 20,000 Hz, plus or minus 1 dB.
- C. Level Adjustment Range: 20 dB minimum.
- D. Maximum Distortion: 1 percent.
- E. Control: Permits adjustment of sensing level of the device.

2.18 OUTLETS

- A. Volume Attenuator Station (VC): Wall-plate-mounted autotransformer type with paging priority feature.
 - 1. Wattage Rating: 10 W unless otherwise indicated.
 - 2. Attenuation per Step: 3 dB, with a positive off position.
 - 3. Insertion Loss: 0.4 dB maximum.
 - 4. Attenuation Bypass Relay: Single pole, double throw. Connected to operate and bypass attenuation when all-call, paging, program signal, or prerecorded message features are used. Relay returns to normal position at end of priority transmission.
 - 5. Label: "PA Volume."
- B. Microphone Outlet: Three-pole, polarized, locking-type, microphone receptacles in single-gang boxes. Equip wall outlets with brushed stainless-steel device plates. Equip floor outlets with gray tapered rubber or plastic cable nozzles and fixed outlet covers.
- C. Headphone Outlet (for the Hearing Impaired): Microphone receptacles in single-gang boxes. Equip wall outlets with brushed stainless-steel device plates. Equip floor outlets with gray tapered rubber or plastic cable nozzles and fixed-outlet covers.

2.19 MODEMS

- A. Provide required quantities of modems for remote diagnostics and system programming of the Public Address and Intercom System, each with the following capabilities; full or half-duplex, auto-dial/auto-answer, monitor speaker with software volume control, nonvolatile memory, tone detection, lightning protection, adaptive equalization, power up analog and digital loop-back diagnostics, and FCC registration.
 - 1. Provide an easily accessible rack-mounted switch that allows the Owner to switch modem between off-line and on-line when interfaced with an available outside CO line.

2.20 BATTERY BACKUP POWER UNIT

- A. Unit shall be rack-mounted, consisting of time-delay relay, sealed lead-calcium battery, battery charger, on-off switch, "normal" and "emergency" indicating lights, and adequate capacity to supply maximum equipment power requirements for one hour of continuous full operation.
- B. Unit shall supply public address equipment with 12- to 15-V dc power automatically during an outage of normal 120-V ac power.
- C. Battery shall be on float charge when not supplying system and to transfer automatically to supply system after three to five seconds of continuous outage of normal power, as sensed by time-delay relay.
- D. Unit shall automatically retransfer system to normal supply when normal power has been reestablished for three to five seconds continuously.
- E. Provide UPS for Public Address and Intercom System.
 - 1. APC Smart-UPS SUA2200RM2U, or approved equal
 - a. Output Power Capacity: 1980 Watts / 2200 VA
 - b. Nominal Output Voltage: 120V

- c. Output Voltage Distortion: Less than 5% at full load
- d. Output Frequency (sync to mains): 47 - 53 Hz for 50 Hz nominal, 57 - 63 Hz for 60 Hz nominal
- e. Waveform Type: Sine wave
- f. Output Connections: (2) NEMA 5-20R and (6) NEMA 5-15R
- g. Nominal Input: Voltage 120V
- h. Input Frequency: 50/60 Hz +/- 3 Hz (auto sensing)
- i. Input Connections: NEMA 5-20P
- j. Surge energy rating: 480 Joules
- k. Filtering: Full time multi-pole noise filtering : 0.3% IEEE surge let-through : zero clamping response time : compliant with UL 1449
- l. Regulatory Approvals: BSMI, CSA, UL 1778, FCC Part 15 Class A
- m. Interface Port(s): DB-9 RS-232, Management Interface Slot, USB
- n. Management interface: included
- o. Manufacturer's Warranty: 2 years repair or replace

2.21 CONDUCTORS AND CABLES

- A. Jacketed, twisted pair and twisted multi-pair, untinned solid copper.
 - 1. Insulation for Wire in Conduit: Thermoplastic, not less than 1/32 in. thick.
 - 2. Microphone Cables: Neoprene jacketed, not less than 2/64 in. thick, over shield with filled interstices. Shield No. 34 AWG, tinned, soft-copper strands formed into a braid or approved equivalent foil. Shielding coverage on conductors is not less than 60 percent.
 - 3. Plenum Cable: Listed and labeled for plenum installation.
- B. Provide and terminate cabling per manufacturers' recommendations for a completely operational system as specified.
- C. At backbox locations, cables shall have a minimum 18 in. service loop coiled in the backbox.
- D. Sound/Speaker cabling shall be home-run and looped directly to the applicable headend termination board, as specified. cable runs shall be free from in-line splices. Insulate cable shields (at field device end) from field grounds by cutting and taping shields.
- E. Classroom speakers, office speakers, conference room speakers, workroom speakers, exterior horn speakers, and other areas that have only one public address speaker shall each be individually home-run, without splices, back to their respective sound or master clock headend. Provide 22 AWG, stranded shielded speaker cables.
- F. Hallways and other areas that have multiple speakers may have a maximum of eight speakers per speaker loop home-run, without splices, back to their respective sound headend. Provide 18 AWG-stranded speaker cables.
- G. Horn Speaker areas that have multiple speakers, may have a maximum of four speakers per speaker loop home run, without splices, back to their respective sound headend. Provide 18 AWG-stranded speaker cables.

2.22 INTERFACES TO OTHER SYSTEMS:

- A. Master Clock System Interface.

1. Provide interface between Master Clock System and Public Address System to allow master clock class change schedules (tones or bells), to be broadcast over applicable public address speakers.
 2. Provide four inputs on the Public Address System for interface to the Master Clock System.
 3. The Master Clock System Subcontractor shall provide applicable interface cables between these two systems and interface to the Master Clock System.
 4. Public Address System Subcontractor shall provide applicable interface ports for the Public Address and Intercom Systems and provide proper interface/programming to their system.
 5. Once properly interfaced, the Master Clock class change schedules (tones or bells), shall be broadcast over applicable Public Address Speakers.
- B. Local Sound System Interface: Provide a 10dB balanced-audio, line-level output from the public address system to each local sound system rack/cabinet/amplifier for the interface.
1. Public Address system Subcontractor shall provide cabling and interface to the public address system.
 2. Local sound system Subcontractor shall interface cabling to the local sound systems to be used for muting of local sound systems audio during public address announcements or interfacing public address audio to the local sound system speakers.
- C. Telephone System Cabling and Interface: The Public Address and Intercom System shall interface to the Telephone System and shall provide capabilities as specified once properly interfaced.
1. Provide two telephone interface ports on the Public Address and Intercom System for interface to the Telephone System by Owner.
 2. The Public Address and Intercom System Subcontractor shall provide applicable interface cables between these two systems and interface to the Public Address System.
 3. Owner's Telephone system vendor shall provide applicable interface ports for the Public Address and Intercom Systems and provide proper interface/programming to their telephone system.
 4. Once properly interfaced, authorized telephones shall be able to access the Public Address and Intercom System from the telephone system handsets and perform the following capabilities:
 - a. All-Call Announcements
 - b. Zone Paging Announcements
 - c. Intercom calls to room speakers
 - d. Initiate class change & emergency tones.
- D. VHF Radio System Cabling and Interface: The Public Address and Intercom System shall interface to the VHF Radio System and shall provide capabilities as specified once properly interfaced.
1. Provide an interface port on the Public Address/ Intercom System and cabling to interface the VHF Radio system. The interface shall allow All-Call Announcements via the VHF radios.
- E. Fire Alarm System interface: provide and terminate a Cat 5E cable between the Public Address/Intercom System and the Fire Alarm Control Panel (FACP). Interface can be used to allow secondary annunciations of Fire Alarm Signals over the Public Address/Intercom System Speakers.

1. Fire Alarm system Subcontractor shall provide applicable interface ports on the Fire Alarm System for the Public Address/Intercom System and proper interface/programming to their Fire Alarm System.
- F. Panic Button/Duress Alert System Interface: Coordinate with the Integrated Electronic Security Division 28 16 00 Subcontractor for the interface to the Panic Button/Duress Alert System Control Panel.
1. Once properly interfaced, the Public Address/Intercom System shall accept and immediately distribute emergency announcement WAV files initiated from the Active Shooter/Duress Alert System Control Panel to PA speakers.
 2. The volume of the emergency announcements shall be loud enough to be heard above the highest possible ambient noise level in each space. Adjust the tap levels of PA speakers accordingly.

2.23 SURGE AND LIGHTNING PROTECTION

- A. Provide Surge and Lightning Protection for exterior aerial copper cables.
- B. Provide Surge and Lightning Protection for copper cables run underground.
- C. All surge and lightning protection devices shall be connected to a low inductive path to earth ground.
- D. All exterior mounted surge and lightning protection devices shall include weatherproof housings.
- E. Provide lightning protection devices with the proper voltage rating for the applicable cable applications, per manufacturer's recommendations
- F. Provide the following.
 1. Surge Protection Device.
 - a. Base: Citel #FP10-110, or approved equal
 - b. Cable Capacity: 10 pairs
 - c. Connector type: 110.
 - d. Module Capacity: 4
 - e. Citel #E280-24V Module, or approved equal used for the applicable applications.
 - f. 25V Public Address.
 - g. 24V Clock Applications.
 - h. 24V Intrusion Alarm.
 - i. 24V Access Control
 - j. Other 24V applications

PART 3 - EXECUTION

3.1 WIRING METHODS

- A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters, and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.2 INSTALLATION OF CABLES

- A. Comply with NECA 1.
- B. General Cable Installation Requirements:
 - 1. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.
 - 2. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
 - 3. Secure and support cables at intervals not exceeding 30 in. and not more than 6 in. from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - 4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
 - 5. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 - 6. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used.
- C. Open-Cable Installation:
 - 1. Back boxes with conduit stubbed above accessible ceilings shall be provided by the Electrical Subcontractor.
 - 2. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 - 3. Suspend speaker cable not in a wireway or pathway a minimum of 8 in. above ceiling by cable supports not more than 60 in. apart.
 - 4. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.
- D. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 in. apart for speaker microphones and adjacent parallel power and

telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.

3.3 INSTALLATION

- A. Delegated Design: Design the Public Address system, including engineering analysis by a qualified manufacturer's certified engineer, using performance requirements and design criteria indicated.
- B. Amplifiers: Quantity of amplifiers in the MDF and placement of local amplifiers in IDF wire closets shall be provided for proper signal levels to all speakers based on speaker loads and cable distances as per manufacturer's recommendations.
- C. Speakers: Tap each and every speaker at the proper level so that volume of all announcements is loud enough to be heard above the highest possible ambient noise level in each space.
- D. impedances and Signal Levels: Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
- E. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.
- F. Equipment Cabinets and Racks:
 - 1. Group items of same function together, either vertically or side by side, and arrange controls symmetrically. Mount monitor panel above the amplifiers.
 - 2. Arrange all inputs, outputs, interconnections, and test points so they are accessible at rear of rack for maintenance and testing, with each item removable from rack without disturbing other items or connections.
 - 3. Blank Panels: Cover empty space in equipment racks so entire front of rack is occupied by panels.
- G. Volume Limiter/Compressor: Equip each zone with a volume limiter/compressor. Install in central equipment cabinet. Arrange to provide a constant input to power amplifiers.
- H. Conductor Sizing: Unless otherwise indicated, size speaker circuit conductors from racks to loudspeaker outlets not smaller than No. 18 AWG and conductors from microphone receptacles to amplifiers not smaller than No. 22 AWG.
- I. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.
- J. Speaker-Line Matching Transformer Connections: Make initial connections using tap settings indicated on Drawings.

3.4 GROUNDING

- A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.

- C. Retain paragraph below for special applications only.
- D. Install grounding electrodes as specified in Section 26 05 26 "Grounding and Bonding."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Tests and Inspections:
 - 1. Schedule tests with at least seven days' advance notice of test performance.
 - 2. After installing public address and mass notification systems and after electrical circuitry has been energized, test for compliance with requirements.
 - 3. Operational Test: Perform tests that include originating program and page messages at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels at each speaker and that system is free of noise and distortion.
 - 4. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:
 - a. Disconnect microphone at connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure signal-to-noise ratio.
 - b. Repeat test for each separately controlled zone of loudspeakers.
 - c. Minimum acceptance ratio is 50 dB.
 - 5. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.
 - 6. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB. In addition, the levels between locations in same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.
 - 7. Power Output Test: Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.
 - 8. Signal Ground Test: Measure and report ground resistance at public address equipment signal ground. Comply with testing requirements specified in Section 26 05 26 "Grounding and Bonding."

- E. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.
- F. See Division 1 Section "Quality Requirements" for retesting and reinspecting requirements and Division 1 Section "Execution Requirements" for requirements for correcting the Work.
- G. Public address and mass notification systems will be considered defective if they do not pass tests and inspections.
- H. Prepare test and inspection reports.
 - 1. Include a record of final speaker-line matching transformer-tap settings, and signal ground-resistance measurement certified by Installer.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
 - 2. Complete installation and startup checks according to manufacturer's written instructions.

3.7 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electronic safety and security installations to restore original fire-resistance rating of assembly. Repair any disturbed fireproof spray material resulting from this work of this Section.

3.8 ACCEPTANCE DEMONSTRATION AND TRAINING

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, program, and maintain the equipment.
 - 1. Engage the Owner in review of the final programming and setup and obtain their acceptance.
- B. Provide a GUI interface and training which will allow the Owner to make changes and adjustments
 - 1. Provide a minimum of ten days' notice of acceptance test performance and training schedule. Schedule tests and training after pretesting has been successfully completed.
 - 2. Provide Operations Manuals to all participants.
- C. Video record all training sessions for all applicable features, functions, programming and operations for owner's future reference.
- D. Obtain Owner sign-off for training and system acceptance and submit as part of Closeout documentation.

3.9 ADJUSTING

- A. On-Site Assistance: Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions.
- B. Occupancy Adjustments: When requested within 24 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions or to make changes as requested by the Owner, or for additional training.
 - 1. Provide up to eight on site visits to Project during other-than-normal occupancy hours for this purpose.

3.10 SYSTEM DOCUMENTATION

- A. Provide all documentation for review ten business days before the substantial completion date for each construction phase.
- B. Provide "Record" drawings indicating location of all equipment. Indicate labeling for each piece of equipment.
- C. Provide "As-built" Drawings for review in electronic format at least the following information. Obtain a copy of original Drawings from the Architect.
 - 1. All speaker locations identified.
 - 2. Riser diagrams shall include:
 - a. One-line diagrams for cabling and clock loops.
 - 3. Floor diagrams shall include:
 - a. Horizontal cabling pathways including penetrations and fire stopping.
 - 4. Provide graphical documentation of final paging zones,
 - 5. Provide copies of approved as-built drawings in hard copy and electronic format to the owner.

3.11 CLEANUP

- A. Upon completion of all work and testing, thoroughly inspect all exposed portions of the installation and completely remove all exposed labels, markings, and foreign material.
- B. The interior of all boxes and cabinets shall be left clean; exposed surfaces shall be cleaned and plated surfaces polished.
- C. Repair damage to finished surfaces resulting from work under this Section.
- D. Remove material and equipment from areas of work and storage areas.
- E. All equipment shall be clean from dirt, dust, and fingerprints prior to final acceptance.
- F. Touch up all damaged pre-finished equipment using materials and methods recommended by the Manufacturer.

3.12 PROJECT CLOSEOUT

- A. Provide close-out submittals as required herein and in Section 01 77 00 – Closeout Procedures, including the following closeout submittals.
 - 1. Operation and Maintenance Manuals.
 - 2. Record Drawings with “as-built” corrections showing
 - a. Speaker locations
 - b. Wiring
 - c. Graphical documentation of paging zones.
 - 3. All Test Reports
 - 4. All Warranties
 - 5. Copies of video recordings of training sessions
 - 6. Extra Materials.
- B. Provide copies of written delivery receipts of materials and/or equipment. Receipts shall specifically detail what was delivered (description, quantity, and specification section) and shall be dated and signed by delivery firm and by an Owner's representative.
- C. Provide copies of all signed training and acceptance documentation.

END OF SECTION

SECTION 275313

CLOCK SYSTEM

(Trade Sub-Sub-Bid Required as part of Section 26 00 00)

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SECTION 275313
CLOCK SYSTEM
(Trade Sub-Sub-Bid Required as part of Section 26 00 00)

PART 1 - GENERAL

1.1 TRADE SUB-BID REQUIREMENTS

- A. The Procurement and Contracting Requirements, as listed in the Table of Contents, and applicable parts of Division 01 - General Requirements shall be included in and made a part of this Section.

1.2 TRADE BID REQUIREMENTS

- A. Trade Contractor on this Project are required by law to provide Payment and Performance Bonds for the full value of his Trade Contract. Trade Contractor must include the full cost of the required Payment and Performance Bonds in the Bid price submitted to complete the Work of this Section. Trade Bids will only be accepted from Trade Contractors pre-qualified by the Awarding Authority.
- B. All Trade-Bids shall be submitted on the Trade Contractor Bid Form, included in the Specifications, in accordance with requirements of Chapter 149A of the Massachusetts General Laws, as amended.
- C. The attention of Trade Bidders is directed to Instructions to Bidders and Paragraph E of the Trade Contractor Bid Form. Trade-Bids shall be filed with the Awarding Authority in accordance with the requirements stipulated therein.

1.3 RELATED DOCUMENTS

- A. All of the Contract Documents, including Drawings, General Conditions, Supplementary Conditions, and all Sections of Division 01 - General Requirements, apply to the Work of this Section.
- B. The Trade Contractor for this Section shall examine all Drawings and all Sections of the Specification for requirements therein that may affect the Work of this Section, not just those Drawings and Specifications particular to the Work of this Section. The Work of this Section is shown primarily on the following listed Drawings:
 - 1. Architectural, "A" Drawings
 - 2. Electrical "E" series drawings
 - 3. Technology and Security drawings: T0-0-1 through T3-1
- B. The listing of the Contract Drawings above shall not limit responsibility to determine full extent of work of this Section as required by: all Contract Drawings noted on the Contract Drawings-Title Sheet Drawing List, the Project Manual, and Addenda.

1.4 SUMMARY

- A. The work under this Section includes the provision of all material, labor, equipment, and supplies and the performance of all operations to provide a complete working Clock System as required by the Drawings and details and as specified herein. Where the Drawings, Specifications, Codes,

Regulations, Laws, or the requirements of the local Authority conflict, provide the higher quality and higher quantity indicated or required and follow the strictest requirement. In general, the work includes, but is not limited to, the following:

1. Master Clock
2. Secondary Analog Clocks
3. Power Supplies
4. Wiring
5. Interface with the intercom public address system
6. Operation and Maintenance Instructions and Manuals for the Section's work.
7. Training
8. System Installation and Setup Documentation

- B. Coordination with the Owner to obtain required bell schedules for programming.
- C. Interfacing the Clock system with the Public Address system.
- D. Provide and maintain in safe adequate condition all staging and scaffolding required for the proper execution of the work of this Section.
- E. Remove and re-install all ceiling tiles as required for the work of this Section.
 1. Replace all ceiling tiles damaged as a result of the work of this section at no cost to the Owner.
- F. Removal of all trash from site and clean up of all areas of work under this SECTION.
- G. Contractor shall perform daily clean-up of areas of work under this section and removal of all trash from the site.
- H. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to ensure the steady progress of all work under the Contract.

1.5 RELATED SECTIONS

- A. Related Sections include the following:
 1. Section 26 00 00 "Electrical"
 2. Section 26 05 26 "Grounding and Bonding"
 3. Section 26 05 33 "Raceways and Boxes"
 4. Section 27 51 15 "Public Address/Intercom System"
- B. Except for coordination, or unless otherwise indicated, the following work is not included as part of the technology Contractor's responsibilities in this SECTION, and is to be performed by others as indicated:
 1. Power Requirements provided by Electrical Contractor.
 2. Costs associated with core drilling and cutting and patching, using appropriate and trained tradesmen approved by the Construction Manager and the Engineer, shall be provided by Electrical Contractor.
 3. Cutting and Patching provided by Electrical Contractor.
 4. Cable tray, ladder rack, and snake tray shall be provided by the Electrical Contractor.

5. Sleeves and empty conduits to an accessible point above the ceiling or below the floor shall be provided by the Electrical Contractor.
6. Standard device boxes with plaster rings shall be provided by the Electrical Contractor.
7. All required specialty boxes shall be furnished by the Contractor and installed by the Electrical Contractor.
8. Public Address / Intercom system cabling and equipment, Section 27 51 15, shall be provided by others under the General Construction Contract.

- C. The installation, operating cost, and maintenance of the controlled environmental conditions for equipment located on-site, as required by the manufacturer, NFPA 70B, or as specified in these specifications, shall be the responsibility of the Construction Manager at Risk.

1.6 DEFINITIONS

- A. Furnish: The term "furnish" is used to mean "supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, and similar operations."
- B. Install: The term "install" is used to describe operations at the project site, including the actual "unloading, unpacking, rigging in place, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations."
- C. Provide: The term "provide" means to "furnish and install, complete and ready for the intended use".
- D. SECTION, Section, and Contract: "SECTION," "Section," and "Contract" refer to the requirements of the work to be performed as specified herein.
- E. Acronyms:
1. AFF – Above Finished Floor
 2. GPS – Global Positioning System.
 3. IDC - Insulation-Displacement Connections
 4. IDF/ICER – Intermediate Distribution Frame or Intermediate Communications Equipment Room
 5. MDF/MCER – Main Distribution Frame or Main Communications Equipment Room
 6. NIST: The National Institute of Science and Technology.
 7. PC: Personal computer.
 8. RMU – Rack Mount Unit
 9. UPS – Uninterruptible Power Supply
 10. UTC: Universal time coordinated. The precisely measured time at zero degrees longitude; a worldwide standard for time synchronization.

1.7 REFERENCES

- A. Comply with applicable requirements of the following standards and those others referenced in their Section.
- B. Materials and equipment shall be manufactured, installed and tested as specified in the latest editions of applicable publications, standards, rulings and determinations of:
1. FCC - Federal Communications Commission
 2. NEC - National Electric Code
 3. NFPA-70 - National Fire Protection Association
 4. FCC Part 15 (addresses electromagnetic radiation).

5. National Electrical Safety Code Handbook. (NESC)
 6. UL - Underwriters Laboratories
- C. Materials and workmanship shall conform to the latest issue of all industry standards, publications, or regulations referenced in this SECTION and with the following references as applicable.
1. NFPA 70 – National Electrical Code.
 2. NFPA 72 – National Fire Alarm Code.
 3. NFPA 101 - Life Safety Code.

1.8 DELIVERY, STORAGE, AND HANDLING:

- A. Do not deliver items to the site until specified submittals have been submitted to, and approved by, the Architect.
- A. Deliver materials in original packages, containers, or bundles bearing a brand name, or identification of manufacturer or supplier.
- B. Deliver, store, protect, and handle products in accordance with recommended practices listed in Manufacturer's Installation and Maintenance Manuals.
- C. Protect materials from damage due to moisture, direct sunlight, excessive temperatures, surface contamination, corrosion, and damage from construction operations and other causes.

1.9 PERFORMANCE REQUIREMENTS

- A. Materials and equipment shall be manufactured, installed, and certified as specified in the latest editions of applicable publications, standards, rulings, and determinations: The Electrical Subcontractor shall comply with and reference the latest editions of the following standards, including related addendum or TSB's not listed below:
 1. ANSI/TIA/EIA-526-7, Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
 2. ANSI/TIA/EIA-526-14-C, Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant
 3. ANSI/TIA/EIA-568-C.0, Generic Telecommunications Cabling for Customer Premises
 4. ANSI/TIA/EIA--568-C.1, Commercial Building Telecommunications Cabling Standard Part 1: General Requirements
 5. ANSI/TIA/EIA-568-C.2, Balanced Twisted-Pair Telecommunications Cabling and Components Standards
 6. ANSI/TIA/EIA-568-C.3, Optical Fiber Cabling Components Standard
 7. ANSI/TIA/EIA -569-D, Telecommunications Pathways and Spaces
 8. ANSI/TIA/EIA--598-D, Optical Fiber Cable Color Coding
 9. ANSI/TIA/EIA-606-B, Administration Standard for Commercial Telecommunications Infrastructure
 10. ANSI/TIA/EIA-607-B, Commercial Building Grounding and Bonding Requirements for Telecommunications
 11. ANSI/TIA/EIA 310D, Cabinets, Racks, Panels and Associated Equipment
 12. BICSI, TDMM, Telecommunications Distribution Methods Manual (TDMM)
 13. BICSI, Information Technology Systems Installation Methods Manual (ITSIMM)
 14. BICSI, Outside Plant Design Reference Manual (OSPDRM)
 15. BICSI, Electronic Safety and Security Design Reference Manual (ESSDRM)

16. ANSI
17. FCC Part 15 (addresses electromagnetic radiation).
18. FCC Part 68 (connection of premises equipment and wiring to the network). NEC – National Electric Code (NEC)
19. National Electrical Safety Code Handbook. (NESC)
20. NFPA-70 – National Fire Protection Association (NFPA – 70)
21. State and Local Building Codes.

1.10 SUBMITTALS

- A. Submit under the provisions of Division 01 Section "Submittal Procedures".
- B. LEED Submittal – refer to Division 01 Sustainable Design Requirements..
 1. LEED submittals are in addition to other submittals. If submitted item is identical to that submitted to comply with other requirements, submit duplicate copies as a separate submittal to verify compliance with indicated LEED requirements.
 2. Project Materials Cost Data: Provide a statement indicating the total cost for materials used for Project.
 3. LEED Action Plans: Provide preliminary submittals indicating how the following requirements will be met:
 - a. Construction Waste Management: in compliance with Division 01 Section "Construction Waste Management."
 - b. List of proposed materials with recycled content: Manufacturers' certification of recycled content indicating percentage by weight of both pre-consumer and post-consumer recycled content.
 - c. Local/Regional Materials:
 - 1) Sourcing location(s): Indicate the location of extraction, harvesting, and recovery of raw materials used in the product's manufacturing; indicate the distance between extraction, harvesting, and recovery and the project site.
 - 2) Manufacturing location(s): Indicate the location of the manufacturing facility; include the distance between the manufacturing facility and the project site.
- C. Submit within (30) days of Contract award and prior to installation of any materials or equipment complete shop drawings, product data and schedule of values to the Architect for approval review.
- D. Provide a Bill of Materials that clearly identifies the information requested herein for each and every item submitted. The Bill of Materials shall include the following "headings" in the order indicated from left to right on the Bill of Materials Index/Equipment List:
 1. Item Number
 2. Manufacturer's "Name" for each item
 3. Manufacturer's "Model No." for each item
 4. Manufacturer's "Description" of each item
 5. "Specification Section Number", reference specification section number/location for the item submitted.
 - a. Example of Specification Section number/location: 2.13, B., 7., c., 4), e), page number.
 6. "Quantity" of each item being provided.

7. Submittal Page Number(s) of data sheet(s) for each item. Each and every specification sheet submitted shall include a page number in the lower right corner of the sheet.

a. Double-sided specification sheets shall be identified by two separate page numbers.

8. Bill of Material Header Example:

Item #	Mfr. Name	Mfr. #	Description	Spec Ref	Qty	Pg #
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9. All Bill of Material items shall be listed in the Bill of Material Index / Equipment List, in the same order as they appear in the specification.

10. On each and every data sheet, indicate the applicable part numbers(s) on the sheet(s) by one of the following methods:

- a. Circling the applicable part number(s)
- b. Putting an arrow next to the applicable part number(s)
- c. Highlighting the applicable part number(s)

11. Shop drawings shall include but not be limited to the following:

- a. Built-in station arrangement.
- b. Equipment cabinet arrangement.
- c. One-line drawings.

12. Include in the submittal:

- a. Warranty information for all components.
- b. Qualification Data: For qualified Contractor.

- E. If proposed equipment deviates from the Specifications or Drawings, indicate in writing on Company letterhead those differences and provide sufficient data to justify acceptance. FAILURE TO INDICATE DEVIATIONS OR SUBSTITUTIONS IMPLIES FULL COMPLIANCE WITH DRAWINGS AND SPECIFICATIONS.

- F. It is intended that Submittal be complete and accurate at the first submission.

- 1. Submit all required Submittal information at one time.
- 2. An incomplete Submittal shall be rejected in its entirety.

- G. A minimum period of (15) working days, exclusive of transmittal time, will be required each time for review of a Submittal or Resubmittal. An additional (20) working days, exclusive of transmittal time, will be required for reviewing substitute materials or manufacturer. These time periods shall be considered by the Contractor when scheduling the work.

- H. No equipment or material shall be used, furnished, or installed unless previously reviewed and accepted by the Architect.

- I. Reviewed submittals on substitute equipment shall only allow the Installer to proceed with installation. The substitution shall not be considered equal until such time as the Owner and Owner's Representative have completely accepted the installation. All costs for removal, relocation, or replacement of said Substitution shall be at the risk of the Installer.

- J. Regardless of any information included in the submittal submitted for review, the requirements of the Drawings and Specifications shall not be superseded in any way by the review. Review by the Architect does not relieve responsibility for submittal errors or from meeting the requirements of the Contract Documents.

1.11 SCHEDULE OF VALUES

- A. As part of the Submittal, provide a Schedule of Values.
- B. Schedule of Values Format
1. Provide a schedule of values to be approved by Owner's representative, itemizing costs by construction phase for each technology system for labor and materials, with additional breakdowns for rough and finish work by construction phases, by system.
 2. The schedule of values shall be submitted for review and acceptance prior to the paying of any invoice.
 3. The schedule of values shall accurately reflect the actual costs for each category, including allocation for overhead and profit.
 - a. As a minimum, provide the following breakdown, by phase where applicable, as indicated:
 - 1) Each major piece of equipment
 - 2) Other equipment by category
 - 3) Material and labor for each item.
 - 4) Equipment installation by category and each major piece of equipment.
 - a) Roughing work.
 - b) Finish work.
 - 5) Bond
 - 6) Testing.
 - 7) Owner Training.
 - 8) Operation and Maintenance Manuals.
 - 9) Record Drawings.

1.12 REGULATORY REFERENCES

- A. Comply with applicable requirements of the following standards and those others referenced in their SECTION.
- B. All work and materials shall conform in every detail to the rules and requirements of the National Fire Protection Association, the local Electrical Code, and present manufacturing standards.
- C. All materials shall be UL Listed and shall be marked as such. If UL has no published standards for a particular item, then other national independent testing standards shall apply and such items shall bear those labels. Where UL has an applicable system listing and label, the entire system shall be so labeled

1.13 QUALITY ASSURANCE

- A. Contractor Qualifications: Manufacturer's authorized representative who is trained and approved for the installation of equipment required for this Project.

- B. The Contractor (Firm and Employees) shall be experienced in the operations they are engaged to perform.
- C. The Contractor must provide documentation as part of the submittal process that they themselves are factory-authorized representatives of all systems specified.
 - 1. The Contractor must customarily furnish the size, scope and nature of this section and must be an authorized manufacturer's representative, certified (if certification program exist with such manufacture), experienced and qualified to provide, install, program, troubleshoot, train, warrant and service all the systems in this section in their entirety.
 - 2. Provide documentation (as part of the submittal process) that the Contractor is authorized by the manufacturer(s) for products to be installed as part of this Section, and are experienced and qualified to provide, install, program, troubleshoot, train, warrant and service all the systems in this Section.
 - 3. Provide documentation (as part of the submittal process) the Contractor holds recent, up-to-date licenses and training certificates for the equipment to be installed.
 - 4. The Contractor must provide (as part of the submittal process) a list of at least five projects (provide the following information for each project: name, address, contact person, title of contact person, telephone number of contact person) of similar size, scope, and nature, and demonstrate that these projects were furnished with persons on Contractor's payroll whom were experienced and qualified to provide, install, program, troubleshoot, train, warrant and service these projects satisfactorily.
 - a. Provide the following information for each project:
 - 1) Name of Project
 - 2) Address
 - 3) Contact Person, Title, and Telephone Number
- B. Testing Agency Qualifications: Qualified agency, with the experience and capability to conduct testing indicated.
- C. Comply with current TIA/EIA Building Telecommunications Wiring Standards and BICSI Telecommunications Distribution Methods and Standards.
- D. Comply with NFPA 70.
- E. Testing Agency Qualifications: Qualified agency, with the experience and capability to conduct testing indicated.
- F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency and marked for intended location and application.

1.14 INTERPRETATION OF DRAWINGS

- A. All work indicated on the Drawings is intended to be approximately correct to scale, but figures, dimensions, and detailed Drawings are to be followed in every case. The Drawings shall be taken in a sense as diagrammatic. The size of raceways and methods of running them are indicated, but it is not intended to show every offset and fitting nor every structural difficulty that may be encountered.
- B. Locations indicated on the Drawings are approximate, and it is intended that all equipment shall be located in accordance with the general and detail Drawings of the construction proper.

Coordinate the location, mounting heights, and routing of cabling work with other trades' requirements and with field conditions.

- C. All measurements shall be taken at the building before fabrication commences.
- D. Schematic diagrams shown on the Drawings indicate the required functions. Standard diagrams of the manufacturer may be used for the functions indicated without exact adherence to the Schematic Drawings shown. Work required for such deviations shall be provided.
- E. Items referred to in singular number in Contract Drawings shall be provided in quantities necessary to complete work.
- F. The right is reserved to make reasonable changes in locations of work prior to rough-in at no additional cost.
- G. Where Drawings or Specifications conflict or are unclear, advise the Architect in writing before the Award of Contract. Otherwise, interpretations of Contract Documents by the Architect shall be final, and no additional compensation shall be permitted due to discrepancies or ambiguities that are resolved according to the Architect's interpretation.
- H. Drawings and Specifications form complementary requirements. Provide work indicated on the Drawings, but not specified, and work specified but not indicated on the Drawings as though explicitly required by both.
- I. Drawings and Specifications do not undertake to indicate every item required to produce a complete and properly operating installation. Materials, equipment, or labor that is not indicated, but that can be reasonably inferred to be necessary for a fully complete, secure, and properly operating installation suitable for the intended use shall be provided.
- J. Drawings do not limit the responsibility of determining the full extent of work required by Contract Documents. Refer to all Drawings and Specifications that indicate types of construction in which work shall be installed and work of other trades with which work of this Section must be coordinated.
- K. Except where modified by a specific notation to the contrary, it shall be understood that the indication or description of any item in the Drawings or Specifications or both carries with it the instruction to provide the item, regardless of whether this instruction is explicitly stated as part of the indication or description.
- L. Where Drawings or Specifications do not coincide with manufacturer's recommendations or with applicable Codes and Standards, alert the Architect in writing before installation. Otherwise, make changes in installed work as the Architect requires without additional cost.
- M. It is the intent of these Contract Documents to have systems and components that are fully complete and operational and fully suitable for the intended use. There may be situations in the documents where insufficient information exists to precisely describe a certain component or subsystem or the routing of a component. In such cases, where the Installer has failed to notify the Architect in writing of the situation prior to Contract Award, the Installer shall provide the specific component or subsystem with all parts necessary for the intended use, fully complete and operational, and installed in a workmanlike manner, either concealed or exposed per the design intent.

- N. In situations where potential conflict exists or where the Installer believes guidance is required, submit a sketch identifying the proposed solution, and the Architect shall review, note if necessary, and return this sketch appropriately marked for use by the Installer.

1.15 OBTAINING INFORMATION

- A. Obtain from the manufacturer the proper method of installation and connection of the equipment that is to be furnished or installed. Obtain all information that is necessary to facilitate the work and to complete the project. Include all such information in Operation and Maintenance Manuals.

1.16 PERMITS, FEES, RULES, AND REGULATIONS

- A. Give the proper Authorities all requisite notices or information relating to the work under this Section. Obtain and pay for all fees, licenses, permits, and certificates. Comply with the rules and regulations of all local, state, and federal authorities having jurisdiction, Building Codes, the rules and regulations of the National Board of Fire Underwriters, and the public utility companies serving the building.
- B. Public utility back charges will be paid for by the Owner and are not to be included in the base bid. Markups on utility back-charges will not be allowed.
- C. Perform work in accordance with Nationally Recognized Testing Laboratory (NRTL) listing or labeling requirements, OSHA regulations, NFPA Standards, Electrical Code, the Americans with Disabilities Act Accessibility Guidelines (ADAAG), EIA/TIA, and BICSI. The Drawings and Specifications do not attempt to indicate all work required by codes, regulations, and authorities.
- D. Nothing in these Contract Documents shall be construed to permit work not conforming to applicable codes and regulations. When conflicts occur, the more restrictive requirements shall govern.
- E. Toxicity: Comply with applicable codes and regulations regarding the toxicity of combustion products used or hazardous materials used or disposed of.
- F. Legally dispose of all material. Adhere to all regulations regarding the disposal of hazardous material. Recycle hazardous material where recycling is possible. Submit certificates of legal recycling or disposal to the Architect. Include a copy in the Owner and Maintenance Manual.
- G. Should the Facility have established building standards, rules, or regulations, obtain a copy from the Building Owner, and comply with them.

H. DELIVERY, STORAGE, AND HANDLING

- I. Do not deliver items to the site until all specified submittals have been submitted to, and approved by, the Architect.
- J. Deliver materials in original packages, containers, or bundles bearing brand name, or identification of manufacturer or supplier.
- K. Deliver, store, protect, and handle products in accordance with recommended practices listed in Manufacturer's Installation and Maintenance Manuals.
- L. Protect materials from damage due to moisture, direct sunlight, excessive temperatures, surface contamination, corrosion, and damage from construction operations and other causes.

1.17 PROTECTION OF WORK AND PROPERTY

- A. Be responsible for the care and protection of all work included under this Section until it has been tested and accepted.
- B. Protect all equipment and materials from damage from all causes, including theft. All materials and equipment damaged or stolen shall be replaced with equal material or equipment at the option of the Architect and Owner.
- C. Materials and equipment stored for this project shall be protected and maintained according to the manufacturer's recommendations and requirements and according to the applicable requirements of NFPA 70B.
- D. Protect all equipment, outlets, and openings with temporary plugs, caps, and covers. Protect work and materials of other trades from damage that might be caused by work or workmen, and make reparations for any damage caused.
- E. Use caution to avoid damage to existing work, and to prevent harm to personnel working in all areas.
- F. Observe all safety precautions and requirements for the construction.
- G. When open-flame or spark-producing tools, such as blower torches and welding equipment, are required in the process of executing the work, the Construction Manager shall be notified not less than twenty-four hours in advance of the time that the work is to begin, and the location where the work is to be performed. Provide, where necessary, fire protective covering and maintain a constant non-working fire watch where work is being performed and until it is completed.
- H. The Construction Manager and the Installer are responsible for initiating, maintaining, and supervising all safety precautions and requirements during construction.

1.18 MATERIAL AND EQUIPMENT STANDARDS

- A. Manufactures:
 - 1. Manufacturers are listed for the purpose of establishing a specification standard for that particular item. Other manufacturers shall be considered for approval, provided they meet or exceed all the specification requirements.
- B. Except where no substitutions are indicated, where materials or equipment are specified by patent proprietary name or name of the manufacturer with the terms "or equal", "or approved equal", such specification is used for the purpose of establishing a standard for that particular item.
- C. If three or more manufacturers are indicated as acceptable without the term "or equal", or "or approved equal", then the material and equipment shall be supplied by one of those indicated and that material and equipment shall conform in all respects to the Drawings and Specifications.
- D. No equipment or material shall be used, furnished, or installed unless previously reviewed and accepted by the Architect.
- E. Substitutions may be offered for review, provided the material, equipment, or process offered for consideration is equal in every respect to that indicated or specified. The request for each substitution must be accompanied by a letter from an Authorized Representative of the manufacturer and the Installer, indicating that the substitution meets or exceeds all specified requirements. Provide a chart listing all

specification Sections for the specified product compared to the substitution product. Provide complete specifications, drawings, or samples to properly appraise the materials, equipment, or process. Acceptance of substitutions shall be based on performance, appearance, use, maintenance requirements, durability, aesthetics, physical arrangement, size, and quality.

- F. If a substitution of materials or equipment, in whole or in part, is made, bear the cost of any changes, engineering, or construction necessitated as a result of said substitution.
- G. Materials shall be new, unused, of recent manufacture, not previously installed, full weight, standard, the best quality of its kind, and acceptable to the Architect.
- H. Provide NRTL-listed or labeled products whenever there are NRTL standards, listings, or labeling available for that product category.
- I. The Specifications or notes and description following a catalog number is basically to identify the item, but may also call for accessories, options, or modifications that are not indicated in the catalog number.
- J. Reviewed submittals on substitute equipment shall only allow the Installer to proceed with installation. The substitution shall not be considered equal until such time as the Architect and Owner's Representative have completely accepted the installation. All costs for removal, relocation, or replacement of said Substitution shall be at the risk of the Installer.
- K. Provide products of one manufacturer for each classification of equipment.
- L. Provide documentation from both the specified Product Manufacturer and the proposed substitute Product Manufacturer with a separate comparative analysis sheet that matches product specification item for item. Substitutes shall not be considered unless accompanied by this documentation.

1.19 SEQUENCING AND SCHEDULING

- A. Coordinate the work of this Section with the respective trades responsible for installing interface work, and ensure that the work performed hereunder is acceptable to such trades for the installation of their work.
- B. Refer to the overall scheduling of the work of the project. Schedule work, process Submittal and order materials and equipment to conform to this schedule, and install work not to delay nor interfere with the progress of the project.
- C. Inform Architect immediately of any delays or potential delays. Furnish manufacturer's letter to verify the order date, equipment delays, expected shipment date, order number, and potential remedies to speed up delivery. Any costs to speed up delivery shall be implemented at no cost to the project if the equipment or material was not ordered as soon as possible after Contract award or within the time frames indicated with the Submittal.
- D. Include premium time required to comply with the project scheduling and phasing.
- E. Be aware of, and plan for project scheduling and phasing. Provide for complete continuous operation of all systems. Coordinate scheduling and phasing with the Architect, Owner, other Trades, and the Construction Manager.

1.20 QUALITY ASSURANCE

- A. All items of equipment shall be designed by the manufacturer to function as a complete system and shall be accompanied by the manufacturer's complete service notes and drawings detailing all interconnections.
- B. The contractor shall be an established communications and electronics contractor that has had and currently maintains a locally run and operated business for at least three years. The contractor shall utilize a duly authorized distributor of the equipment supplied for this project location with full manufacturer's warranty privileges.
- C. The contractor shall show satisfactory evidence, upon request, that the supplier maintains a fully equipped service organization capable of furnishing adequate inspection and service to the system. The supplier shall maintain at his facility the necessary spare parts in the proper proportion as recommended by the manufacturer to maintain and service the equipment being supplied.
- D. Electrical Component Standard: Provide work complying with applicable requirements of NFPA 70 "National Electrical Code" including, but not limited to:
 - 1. Article 250, Grounding.
 - 2. Article 300, Part A. Wiring Method.
 - 3. Article 310, Conductors for General Wiring.
 - 4. Article 725, Remote Control, Signaling Circuits.
 - 5. Article 800, Communication Systems.
- E. Installation and startup of all systems shall be under the direct supervision of a local agency regularly engaged in the installation, repair, and maintenance of such systems. The supplier shall be accredited by the proposed equipment manufacturers.
- F. The agency providing equipment shall be responsible for providing all specified equipment and mentioned services for all equipment as specified herein. The agency must be a local authorized distributor of all specified equipment for a single source of responsibility and shall provide documents proving such. The agency must provide written proof that the agency is adequately staffed with factory-trained technicians for all of the specified equipment. The agency must have established business for and currently be providing all services for the equipment.
- G. The contractor shall guarantee the availability of local service by factory-trained personnel of all specified equipment from an authorized distributor of all equipment specified under this section.
- H. The supplier shall visit the sites and familiarize himself with the existing conditions and field requirements prior to submitting a proposal.

1.21 WARRANTY

- A. Provide a warranty for two years against defects in material and workmanship on all components, equipment, software, systems, cabling, and installation/setup. Warranty shall start at the time of substantial completion or routine use, whichever comes first. Warranty shall include all materials, equipment, and work furnished or installed under this Section. Any failure due to defective material, equipment, installation, or workmanship that may develop shall be corrected at no expense to the Owner, including all materials, labor, travel, expenses, system diagnostics, and damage to areas, materials, and other systems resulting from such failures.

- B. Additionally, all manufacturer supplied products must be covered by three years (parts only) limited warranty from the date of acceptance. The warranty period shall begin on the date of acceptance by the Owner.
- C. Manufacturers shall provide replacement warranties for material and equipment furnished under this Section. Such warranties shall be in addition to, and not in lieu of, all liabilities that the Manufacturer and the Installer may have by law or by provisions of the Contract Documents.
- D. Include copies of all warranties, maintenance contracts, and training contracts or performance bonds in the Operation and Maintenance Manuals.

1.22 MAINTENANCE

- A. Provide an installer's maintenance contract equal to the warranty period.
- B. Upon receipt of notice from the Owner of a failure of any part of the systems during the warranty period, the affected parts shall be replaced. Any equipment requiring excessive service, consisting of more than two unscheduled service calls, shall be considered defective and shall be replaced.
 - 1. Response times to warranty issues shall differ according to the level of the problem.
 - 2. A problem is considered to be corrected when the system and its components operate according to specified requirements.
 - 3. Warranty work shall be performed according to the procedures of the Owner, its staff and tenants, and their normal operations.
 - 4. The following levels of response to problems are required:
 - 5. Major Failure: 4-hour maximum response time if notified by telephone, 24 hours per day, 365 days per year.
 - 6. Minor Failure: 24 hours maximum response time if notified by telephone, 365 days per year.
 - 7. Failures are defined as follows:
 - a. Major Failure: a system failure that disables the entire system or major part of the system, or an individual critical piece of equipment that prevents the proper operation of more than one system component.
 - b. Minor Failure: a system failure that affects only one non-critical component and does not affect operation of any other components or any failure that is not defined as a major failure.
 - c. Major and minor failures are as defined by the Owner.
 - d. Response time to a call is defined as the time at which a qualified technician arrives at the site and starts repairs or diagnostics. If the problem has not been corrected within two hours of the initial response, regional and/or national support personnel shall be contacted for assistance.
- C. Adequate stocks of parts and components and access to regional and national support personnel shall be available such that all major failures shall be corrected within 8 hours of the Owner's initial telephone call, and all minor failures within 48 hours. Temporary components may be used to meet this requirement while new components or repairs are completed. Temporary components shall be replaced with new (unused) components or the original component repaired as soon as practical. Remanufactured equipment or components are not considered new and shall not be used.
- D. Provide certified factory-trained technical service personnel for service and maintenance of the system.
- E. Provide a copy of this warranty section in the Operations and Maintenance Manuals. Each copy shall be dated, signed, and certified by an authorized Representative of the Installer providing work under this Section stating that these requirements are understood and will be complied with without exception.

- F. The contractor shall, at the Owner's request, make available a service contract offering continuing factory-authorized service of the system after the initial warranty period.

1.23 CERTIFICATES OF APPROVAL

- A. Upon completion of all work, and as a condition to receiving payment at Substantial Completion, furnish to the Architect the following original, signed certificates, and include copies of these certificates as part of the Operation and Maintenance manuals:
 - 1. Certification from the manufacturer's authorized representative stating that authorized factory engineers have inspected and tested the operation of their respective equipment and found same to be installed in accordance with the manufacturer's requirements, all requirements for manufacturer's warranties are complied with, and equipment is in satisfactory operating condition. This certification shall be provided for each piece of major equipment and for all complete systems. Provide certificate for additional items requested by the Architect.
 - 2. Certificates of inspection, letters, or notices from the appropriate governmental authorized inspection authorities stating that all portions of the work (indicate trade and responsibility) have been inspected and are installed in conformance with the applicable codes, laws, ordinances, and referenced standards. If non-conformance notices are received, include the re-inspection certificate, letter of explanation as required to indicate complete conformance. Provide written evidence of all exceptions or variances given by any Inspector.
 - 3. Certificate from the installing firm responsible for the work (indicate trade and responsibility) signed by an authorized Officer of the firm and the Foreman or Project Manager in charge, indicating trade license numbers and stating that to the best of the signer's knowledge and belief that the project (indicate project name and address) has been installed in compliance with the Contract Drawings, Specifications, and Addenda, and all applicable codes, laws, ordinances, and referenced standards. Where sub-contractors perform a portion of the work of this Section, include certificates from them.

1.24 SUBSTANTIAL AND FINAL COMPLETION

- A. Refer to General Conditions and Supplementary Conditions.
- B. Substantial Completion shall not be considered unless all systems are tested and verified for adherence with Contract Documents and any work remaining is less than one percent of the total Contract Value of this Section.
 - 1. Record Drawings, Operation and Maintenance Manuals, Acceptance Demonstrations, Owner personnel training, spare parts or extra materials required, test reports, warranties and certifications of installation inspections shall be submitted and accepted prior to Substantial Completion.
- C. Final Completion shall be when all work under this Section is completed as defined by the Contract Documents and accepted by the Architect.
- D. Upon completion of all work under this Section, submit written certifications that:
 - 1. Contract Documents including addenda, clarifications, change orders, RFIs, and instructions from Architect have been reviewed.
 - 2. Work has been inspected for compliance with Contract Documents.
 - 3. Work has been completed in accordance with Contract Documents, and any deficiencies listed with Certificate of Substantial Completion have been corrected.

4. Equipment and systems are fully operational.
5. Work is complete and ready for Architect's final review.

E. When Architect determines Work is complete, close out submittals will be considered.

1.25 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS

A. At least (30) days prior to Substantial Completion, submit for review three sets of Operating and Maintenance Manuals containing the Manufacturer's catalogs and other similar data, including the necessary photographic equipment cuts, wiring diagrams, and final reviewed Shop Drawings and Product Data covering all equipment and devices furnished or installed under this Section. These manuals shall provide complete instructions for the proper operation and use of the equipment, together with instructions for lubrication and periodic maintenance and for trouble shooting. Operating instructions shall be specific for each system and shall include copies of posted specific instructions. This manual shall contain only information that specifically applies to this project, and all unrelated material shall be deleted or clearly crossed out.

B. The Owner and Maintenance Manual material shall be bound in 3-ring binders and indexed.

1. On the edge of the binder, provide a clear see-through plastic holder with a typed card indicating the Project name, the Architect's name, the installer's name, and the Volume number (e.g., Vol. No. 1 of 2).
2. Index shall identify the page number(s) or section divider number for each item.
3. The Owner and Maintenance Manual Index column headings shall identify the following minimum information. Manuals must be submitted using the following "headings" in the order indicated from left to right on the Index:
 - a. "Description" of each item
 - b. "Manufacturer's" Name for each item
 - c. Manufacturer's "Model #" for each item
 - d. Owner and Maintenance Manual "Page" Number(s) or "Section" Divider Number for each item.

C. Provide the name, address, and telephone number of the manufacturer's representative and service company for all items supplied, so that the source of replacement parts and service can be readily obtained.

1. Include copies of manufacturer's and installer's warranties and maintenance contracts, and performance bonds properly executed and signed by an authorized representative.

D. Include copies of all test reports and certifications.

E. Include copies of all Warranties.

1.26 SEISMIC REQUIREMENTS

A. Equipment and work shall meet the restraint requirements for a Seismic Zone - 2 location, including installation and connections of material and equipment to the building structure.

PART 2 - PRODUCTS

2.1 SYSTEMS DESCRIPTION

- A. A timekeeping system consisting of a programmable master clock, analog clocks, and accessory or optional components for expanding the system and its operations that is capable of synchronizing clocks and computers throughout the facility on a daily basis. The master clock shall be interfaced to the PA system to provide tones over the PA system determined by programmable master schedules.
- B. The system shall synchronize all analog clocks. The system shall utilize GPS technology to provide atomic time to components. Clocks shall automatically adjust for Daylight Saving Time per the Daylight Saving time settings in the Master Clock.
- C. Analog Clocks shall synchronize to +/- 1 second of the master clock displayed time.
- D. The system shall include an internal real-time clock reference so that failure of the GPS signal shall not cause the clocks to fail in indicating the correct time.
- E. The system shall incorporate a "fail-proof" design so that a temporary power interruption shall not cause failure of the system. Upon restoration of power, the system shall resume normal operation.
- F. The system shall include an optional notification pager or communication method to notify a local supervisor or maintenance personnel when the pager is active and the master is transmitting to verify signal reception.
- G. Analog clocks shall be AC-powered for many years of maintenance-free operation.
- H. Master Clock shall be separate from the PA system. Systems using a mater clock integrated with the PA system shall not be accepted.

2.2 MANUFACTURERS:

- A. Manufacturers are listed for the purpose of establishing a specification standard for that particular item. Other manufacturers shall be considered for approval, provided they meet or exceed all the specification requirements.
- B. Acceptable manufacturers:
 - 1. American Time and Signal Co.
 - 2. Bogen Time Systems
 - 3. Sapling Inc.
 - 4. Telecor Inc.
- C. System Requirements, Equipment, and Materials:
 - 1. Time programming shall be accomplished by way of a microprocessor-based and user-programmable master control system. The unit will further permit programming, diagnostics, and activity logging through a connection to an external computer.
 - 2. Correction to the second: the master time controller shall provide correction to the second to all secondary clocks.
 - 3. The master time controller shall provide the following functions:

4. Capacity for storing 350 events and up to 100 Holidays in nonvolatile memory.
5. Ability to review, edit, and delete events
6. Review events from any entered time of day
7. Events shall be programmable to any or all of eight zone circuits
8. Selection of any of eight schedules to allow flexibility due to seasonal changes or special events
9. Fully automatic Holiday program execution.
10. User-programmable Automatic Daylight Savings Time Change
11. Separate bell duration for each zone circuit
12. Latched operation of zones to control lighting or other devices
13. Interface with most types of secondary slave clocks, whether synchronous, wired, or electronic. This shall be accomplished without the use of external synchronous adapters. The master time controller shall be capable of correcting both analog and digital-style secondary clocks.
14. User-programmable custom slave clock correction. Output relays rated at five amperes shall be provided on all zone circuits.

2.3 MASTER CLOCK

- A. Description: Microprocessor-based, software-controlled unit complying with Class A device requirements in 47 CFR 15.
1. Programming and control switches.
 2. Informational Display: LED or backlit LCD type.
 3. Normally shows the current time, date, and day of the week display.
 4. Provides programming cues when the system is being programmed.
 5. Output Circuits for Power and Correction of Secondary Indicating Clocks:
 6. Wired Synchronous Clock Power-and-Correction Circuits: For analog clocks, a minimum of one is required. Relay controlled.
 7. Data Output Port for Secondary Clock Correction Circuit: RS485 or similar circuit for scheduled periodic correction signals.
 8. Modem and PC interface software suitable for remote programming.
 9. Circuits for Audible Signal Devices: Relay controlled, manually switchable, using controls on the master clock. Rated 120-V ac, 15 A minimum. A minimum of two circuits.
 10. Circuits for Programmable Switching of Remote Equipment and Circuits: Relay controlled, manually switchable, using controls on the master clock. Rated 120-V ac, 15 A minimum. A minimum of two circuits.
 11. Power Supplies: Capacity for internal loads and power-and correction circuits of connected clocks.
 12. Enclosure: Metal cabinet with locking front panel. When the cabinet is locked, display indication shall be visible on or through the front panel face. Arrange cabinet for surface, semi-recessed, or flush mounting as indicated.
- B. Battery Backup for Time Base: Lithium battery to maintain the timekeeping function and retain the programs in memory during outage of normal AC power supply for up to 10 years.

2.4 SECONDARY INDICATING CLOCKS

- A. Analog Clock: Equipped with a sweep second hand. Movement shall be driven by a self-starting, permanently lubricated, sealed synchronous motor equipped with a correcting solenoid actuator or be a microprocessor-based, second impulse unit compatible with the master clock.

B. Power Connection for Secondary Indicating Clocks: Plug connector.

C. Secondary Indicating Clock Characteristics:

1. Analog Secondary Clocks shall be synchronous types with full 12 in. face (unless otherwise indicated for 16 in. clocks) for exceptionally high readability. The Analog Clocks shall operate from a 24-volt 60 Hz AC source. Each clock shall be powered by a 60 Hz synchronous motor. The clock shall be a standard 12-hour display with black numerals at least 1 ¼ inches high. Provide clocks by Sapling or approved equal. Semi-flush mounted clocks require a standard two-gang backbox.
2. All Clocks shall include shatterproof Lexan lenses; standard glass crystal lenses shall not be acceptable.
3. All Clocks shall include Hour, Minute, and Second hands.
4. Correction to the second: the master time controller shall provide secondary clock correction every 60 seconds to all clocks.
5. All clocks shall include metal cases. Plastic cases shall not be acceptable.
6. All clocks shall include a plastic clock face. Paper clock faces shall not be acceptable.
7. All flush-mounted clocks shall require the use of a wall box per manufacturer recommendations.
8. All surface-mounted clocks shall require a standard two-gang electrical wall box for installation..

2.5 Provide Converter Boxes: Provide quantity as recommended by the manufacturer determined by the type of clocks, the wire gauge of the electrical wire used for installation, and the distance between the converter box and the last clock in the run.

Specifications:

Color:	Black
Mounting:	Rack or Wall Mount
Weight:	6.2 lbs. (2.81 kg)
Housing dimensions: (LxWxD)	11"x 7" x 3.49" (27.94 cm x 17.78 cm x 8.86 cm) Fits in 19" Rack - 2U Height
Input voltage:	100 - 240 VAC 50-60 Hz
Input signal:	RS485 or 2 Wire Digital Communication
Output current:	5.5 amps
Output voltage:	± 24 Volts DC
Diagnostic LEDs:	Load tolerance LED: 80% of 5.5 Amp

2.6 GUARDS

A. Description: Formed steel wire, shaped to fit around guarded device, with 1 in. maximum clearance.

B. Wire Guards: (Provide As Required)

C. Fabricated from 6 and 9-gauge steel rods

1. Welded

2. Zinc coated
3. Hinged
4. Fixed tabs for mounting independent from the clock

2.7 INTERFACES:

A. Public Address System Interface.

1. Provide an interface between Master Clock System and Public Address System to allow master clock class change schedules (tones or bells), to be broadcast over applicable public address speakers.
 2. Provide four ports on the Master Clock System for interface to the Public Address System.
 3. The Master Clock System Contractor shall provide applicable interface cables between these two systems and interface to the Master Clock System.
 4. The Public Address System Contractor shall provide applicable interface ports for the Public Address and Intercom Systems and provide proper interface/programming to their system.
 5. Once properly interfaced, the Master Clock class change schedules (tones or bells), shall be broadcast over applicable Public Address Speakers.

B. Data Network Interface

1. Connect the master clock to the data network in the Head End/MDF Room and coordinate with school IT personnel to provide Internet access for system time synchronization.

2.8 MODEMS

- A. Provide required quantities of modems for remote diagnostics and system programming of the Master Clock System, each with the following capabilities: full or half duplex, auto dial/auto answer, monitor speaker with software volume control, nonvolatile memory, tone detection, lightning protection, adaptive equalization, power-up analog and digital loop-back diagnostics, and FCC registration.

2.9 WIRING

- A. Provide wiring as per the manufacture's recommendations to ensure each secondary clock has the proper voltage and is able to synchronize with the master clock properly.
- B. Provide wiring as per the manufacture's recommendations to ensure each secondary clock has the proper voltage and is able to synchronize with the master clock properly.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that construction is complete in spaces to receive equipment and that rooms are clean and dry.

3.2 FIELD INSPECTION

- A. Prior to final acceptance, inspect each system component to function properly and replace parts that are found defective.

3.3 MANUFACTURER SERVICES

- A. If needed, provide technical assistance, as demonstrated in the manufacturer's system user guide, on product start-up and system setup, to owners or installers representatives via phone, fax, or e-mail.

3.4 WORK

- A. Loose materials shall not be stored on-site. A "gang box" is acceptable to be placed in a location agreeable to the Owner and the Construction Manager. The Installer is responsible for all equipment and materials and for their delivery until the system is deemed complete and accepted by the Owner.
- B. A trailer may be used for the storage of materials to be located on the Owner's property at a location designated by the Owner and the Construction Manager. Such on-site storage shall be kept locked by the Installer. Security for the trailer and its contents shall be strictly the responsibility of the Installer.
- C. Protect existing spaces where work is being performed to protect them from damage and from the accumulation of dirt.
- D. Any ceilings, walls, floors, furniture, equipment, or furnishings damaged by the work of this Section shall be replaced or at the Owner's option, repaired with similar materials, workmanship, and quality.
- E. Work includes a field survey of existing conditions, systems, equipment, and tracing of existing circuits in order to determine the scope of work.
- F. Maintain the existing building in operation at all times during the entire construction period. If it is necessary to have a system shutdown, a written request for approval shall be submitted in advance, stating the estimated shutdown time. Work shall be planned to minimize shutdown. Shutdowns shall be at the convenience of the Owner and, if necessary, on premium time.
- G. Clean and touch up all equipment, materials, and work sites at the completion of work in each area.
- H. Certain portions of the work area may be occupied during construction. Determine which areas and schedule work accordingly, and include necessary premium time.
- I. Ensure necessary provisions are made to provide continuous service of all existing systems throughout all occupied areas.

J. Existing System Operation:

1. It is imperative that completely operable and operating computer systems be maintained in all areas of the building where such operation is provided.
2. Temporary and short-interval interruptions of the capability of a single existing system zone, in any area of the building, to operate to complete installation of the building network according to the building construction phases may be tolerated with the express written permission of the Owner. This permission will only be considered if a written request for such an interruption is made before the actual need therefore.

3.5 SYSTEM INSTALLATION

- A. Install in accordance with the manufacturer's installation manual furnished with the system for proper installation of each system component.
- B. Install Master Clock and Transmitter in Head End Room.
- C. Install power supplies as required to ensure proper voltage at each clock.
- D. Furnish and install Clocks at locations indicated on the drawings.
- E. Install Wire Guards at locations indicated on the drawings. Secure to a wall using approved theft-resistant Fasteners.

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 1. Perform operational system tests to verify compliance with the Specifications and make adjustments to bring the system into compliance. Include operation of all modes of clock correction and all programming and manually programmed signal and relay operating functions.
 2. Verify each clock has the proper voltage and is synchronized with the master clock.
 3. Verify that units and controls are properly labeled, and that interconnecting wires and terminals are identified.

3.7 ACCEPTANCE DEMONSTRATION AND TRAINING

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, program, and maintain the equipment.
 1. Engage the Owner in a review of the final programming and setup and obtain their acceptance.
- B. Final Acceptance Testing and Training:
 1. Provide a GUI interface and training which will allow the Owner to make changes and adjustments
 2. Provide a minimum of ten days' notice of acceptance test performance and training schedule. Schedule tests and training after pretesting has been successfully completed.
 3. Provide Operations Manuals to all participants.

- C. Video record all training sessions for all applicable features, functions, programming and operations for Owner's future reference.
- D. Obtain Owner sign-off for training and system acceptance and submit as part of Closeout documentation.

3.8 ADJUSTING

- A. Program system according to Owner's requirements. Set the system so signal devices operate on Owner-required schedules and are activated for durations selected by Owner. Program equipment-control output circuits to suit Owner's operating schedule for equipment controlled.
- B. Adjust the sound-output level of adjustable signal devices to suit the Owner's requirements.
- C. Occupancy Adjustments: When requested within 24 months of the date of Substantial Completion, provide on-site assistance in adjusting the system to suit actual occupied conditions or to make changes as requested by the Owner, or for additional training.
 - 1. Provide up to eight visits to the Project during other-than-normal occupancy hours for this purpose.

3.9 SYSTEM DOCUMENTATION

- A. Provide all documentation for review ten business days before the substantial completion date for each construction phase.
- B. Provide "Record" drawings indicating the location of all equipment. Indicate labeling for each piece of equipment.
- C. Provide "As-built" Drawings for review in electronic format at least the following information. Obtain a copy of the original Drawings from the Architect.
 - 1. All clock locations identified
 - 2. Riser diagrams shall include
 - a. One-line diagrams for cabling and clock loops.
 - 3. Floor diagrams shall include:
 - a. Horizontal cabling pathways, including penetrations and fire stopping.
 - 4. Provide documentation of final bell schedules,
 - 5. Provide copies of approved as-built drawings in hard copy and electronic format to the Owner.

3.10 CLEANUP

- A. Upon completion of all work and testing, thoroughly inspect all exposed portions of the installation and completely remove all exposed labels, markings, and foreign material.
- B. The interior of all boxes and cabinets shall be left clean; exposed surfaces shall be cleaned and plated surfaces polished.

- C. Repair damage to finished surfaces resulting from work under this Section.
- D. Remove material and equipment from areas of work and storage areas.
- E. All equipment shall be clean from dirt, dust, and fingerprints prior to final acceptance.
- F. Touch up all damaged pre-finished equipment using materials and methods recommended by the Manufacturer.

3.11 PROJECT CLOSEOUT

- A. Provide close-out submittals as required herein and in Section 01 77 00 – Closeout Procedures, including the following closeout submittals.
 - 1. Operation and Maintenance Manuals.
 - 2. Record Drawings with "as-built" corrections
 - 2. Documentation of bell schedules.
 - 3. All Test Reports
 - 4. All Warranties
 - 5. Copies of video recordings of training sessions
 - 6. Extra Materials.
- B. Provide copies of written delivery receipts of materials and equipment. Receipts shall specifically detail what was delivered (description, quantity, and specification section) and shall be dated and signed by the delivery firm and by an Owner's representative.
- C. Provide copies of all signed training and acceptance documentation.

END OF SECTION

SECTION 280800

ELECTRONIC SAFETY AND SECURITY SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 RELATED SECTIONS

- A. Division 23 – Heating, Ventilating and Air Conditioning
- B. Division 28 - Electronic Safety and Security Systems
- C. Section 019113 - General Commissioning Requirements

1.3 REQUIRMENTS

- A. The Commissioning process requires the participation of Division 28, Electronic Safety and Security, to ensure that all systems fulfill the functional and pre-functional requirements set forth in these construction documents. The general commissioning requirements and coordination are detailed in Section 019113. Division 28, Electronic Safety and Security, shall fulfill commissioning responsibilities assigned to division 28 in accordance with Section 019113.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 PRE-FUNCTIONAL CHECKLISTS

- A. Pre-functional checklists assist in the process to document that the equipment and systems are installed properly.
 - a. The contractor will be provided with construction checklists from the CA for completion. The contractor shall complete the checklists as provide the CA with completed copies in accordance with 019113.
 - b. See attached for a sample pre-functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.2 FUNCTIONAL PERFORMANCE TESTING

- A. Intent of functional performance testing is to prove thru functional test procedures proper system operation.

- B. The contractor will be provided with functional performance test procedures to perform while CA witnesses. The contractor shall perform functional tests in accordance with 019113.
- C. See attached for a sample functional performance test checklist, attached is included only to provide sample of a typical process and scope.

3.3 PREFUNCTIONAL CHECKLISTS AND FUNCTIONAL PREFORMANCE TESTING

- c. Pre-Functional Checklists and Functional performance testing procedures will be performed on the following system types. (Pre Functional and Functional performance testing requirements are in addition to and do not replace any testing required elsewhere in Division 28 or by applicable codes.) Equipment specifically marked as such below shall be provided with start-up of equipment by factory-authorized service representative.
 - 1) Fire Alarm Systems
 - 2) Security systems

3.4 SAMPLE CHECKLISTS

- A. See Attached.

END OF SECTION

SAMPLE ONLY

Contractor Checklist and Functional Test Procedures

SECURITY SYSTEM - Access Control and Video Surveillance

1. Participants

Discipline	Name	Company
CxA		
Mechanical		
Controls		
TAB		
Plumbing		
Electrical		
Date Returned to CxA		

2. Prerequisite Checklist

Check	Description
<input type="checkbox"/>	The above equipment and systems integral to them are complete and ready for functional testing.
<input type="checkbox"/>	All control system functions for this and all interlocking systems are programmed and operable per contract documents, including final setpoints and schedules with debugging, loop tuning and sensor calibrations completed.
<input type="checkbox"/>	Test and balance completed and approved for the hydronic systems and terminal units connected
<input type="checkbox"/>	All A/E punchlist items for this equipment corrected.
<input type="checkbox"/>	Safeties and operating ranges reviewed.
	Schedules and reviewed
	<ul style="list-style-type: none">This checklist does not take the place of the manufacturer's recommended checkout and startup procedures.Items that do not apply shall be noted with the reasons on this form (N/A = not applicable, BO = by others).Contractors assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off.

3. Installation Checks

Check		Comments
General Installation		
Surfaces, coatings, finishes and equipment is without damage	<input type="checkbox"/>	
All wiring fastened and tied in an approved workmanship manner	<input type="checkbox"/>	
All material and equipment new and unused		
Entry Access Control System:		
3 x 5 Color Video Sentry Tilt System installed	<input type="checkbox"/>	
Color Monitor is operational	<input type="checkbox"/>	
Audio operational	<input type="checkbox"/>	

SECTION 28 16 00

INTEGRATED ELECTRONIC SECURITY SYSTEMS
(Trade Sub-Sub-Bid Required as part of Section 26 00 00)

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SECTION 28 16 00

INTEGRATED ELECTRONIC SECURITY SYSTEMS (Trade Sub-Sub-Bid Required as part of Section 26 00 00)

PART 1 - GENERAL

1.1 TRADE SUB-BID REQUIREMENTS

- A. The Procurement and Contracting Requirements, as listed in the Table of Contents, and applicable parts of Division 01 - General Requirements shall be included in and made a part of this Section.

1.2 TRADE BID REQUIREMENTS

- A. Trade Contractors on this Project are legally required to provide Payment and Performance Bonds for the full value of his Trade Contract. Trade Contractor must include the full cost of the required Payment and Performance Bonds in the Bid price submitted to complete the Work of this Section. Trade Bids will only be accepted from Trade Contractors pre-qualified by the Awarding Authority.
- B. All Trade-Bids shall be submitted on the Trade Contractor Bid Form, included in the Specifications, in accordance with requirements of Chapter 149A of the Massachusetts General Laws, as amended.

1.3 RELATED DOCUMENTS

- A. All the Contract Documents, including Drawings, General Conditions, Supplementary Conditions, and all Sections of Division 01 - General Requirements, apply to the Work of this Section.
- B. The Trade Contractor for this Section shall examine all Drawings and all Sections of the Specification for requirements therein that may affect the Work of this Section, not just those Drawings and Specifications particular to the Work of this Section. The Work of this Section is shown primarily on the following listed Drawings:
 - 1. Architectural, "A" Drawings
 - 2. Electrical "E" series drawings
 - 3. Technology and Security drawings: T0-0-1 through T3-1
- C. The listing of the Contract Drawings above shall not limit responsibility to determine the full extent of work of this Section as required by all Contract Drawings noted on the Contract Drawings -Title Sheet Drawing List, the Project Manual, and Addenda.

1.4 SUMMARY

- A. The work under this Section includes the provision of material, labor, equipment, and supplies and the performance of operations to provide a complete working Integrated Electronic Security System, as indicated on the Drawings and details and as specified herein. Where the Drawings, Specifications, Codes, Regulations, Laws, or the requirements of the local Authority conflict, provide the higher quality and higher quantity indicated or required and follow the strictest requirement. In general, the work includes, but is not limited to, the following:

1. Provide an IP-based Integrated Electronic Security system consisting of but not limited to the following.
 - a. A CCTV Network Video Surveillance Enterprise System including but not be limited to the following.
 - 1) A Video Management Server with the latest version of Genetec Security Center software
 - 2) Network Video Recorder and Storage
 - 3) H.264 IP CCTV Cameras
 - 4) Camera Mounting Accessories and adapters
 - 5) Camera Licenses
 - 6) PC Workstations
 - 7) 3-year Hardware Warranty
 - 8) Materials and labor to interface to the Active Shooter / Duress Alert system
 - 9) All low voltage wiring and terminations except for IP (data) cabling.
 - 10) Low voltage cabling and programming to interface electronic door hardware, ADA door actuators, and door operators to the access control system.
 - 11) Materials and labor to integrate the system with the Network Video Surveillance system for monitoring, alarm, and control functions.
 - 12) Materials and labor to interface to the Active Shooter / Duress Alert system
 - b. A Door Access Control System including but not be limited to the following.
 - 1) An Access Control Server with the latest version of Genetec Security Center software
 - 2) Intelligent Controllers
 - 3) Proximity readers
 - 4) Proximity cards/fobs.
 - 5) All low voltage wiring and terminations except for IP (data) cabling.
 - 6) Low voltage cabling and programming to interface electronic door hardware, ADA door actuators, and door operators to the access control system.
 - 7) Materials and labor to integrate the system with the Network Video Surveillance system for monitoring, alarm, and control functions.
 - 8) Materials and labor to interface to the Active Shooter / Duress Alert system
 - c. Wireless Entry Alert Door Chime Systems
 - d. A Digital Control Intrusion Detection system including but not be limited to the following.
 - 1) Hard-wired, modular, microprocessor-based controls
 - 2) Cellular Dialer Back Up
 - 3) Control Panels
 - 4) Zone Expanders
 - 5) Power Supplies
 - 6) Keypads
 - 7) Door Contacts
 - 8) Intrusion Sensors and Detection Devices
 - 9) Dual Tone Sirens and Blue Strobe Beacons
 - 10) Telephone Interface and Dialer
 - 11) All low voltage wiring and terminations except for IP (data) cabling.
 - 12) All devices, cabling, materials, and installation for an intrusion detection system shall be included.
 - 13) Materials and labor to interface to the Panic Button/Alert System system

- e. A Panic Button/Duress Alert System including but not limited to the following.
 - 1) Panic Buttons
 - 2) Relays
 - 3) Beacon/Strobe lights
 - 4) Cabling
 - 5) Materials and labor to interface to the Intrusion Alarm Dialer, the Access Control System, and the Public Address system
 - 6) Data switches and equipment for a Physically Separate IP Security Network for Building Systems including but not limited to the following.
 - a) 10GbE Data Switches
 - b) Switch Modules
 - c) SFP Transceivers
 - d) Cat 6e UTP Patch Cables
 - e) Multi-mode Fiber Patch Cables
 - f) Materials and labor to interface the IP Security/Building System Network Core Switch to the School's Production Network Core Switch
 - f. An IP-based Exterior Door Audio / Video Intercom System including but not limited to the following.
 - 1) Door stations
 - 2) Master Stations
 - 3) Power Supplies
 - 4) All low voltage wiring and terminations except for IP (data) cabling.
 - 2. Provide installation and programming of systems under the work of this Section as required by the Owner.
 - a. Coordinate with the Owner for installation and programming requirements of each system prior to the beginning of work.
 - b. Provide programming to ensure integration of systems under the work of this Section.
 - c. Review the field of view of each CCTV camera with the Owner and make adjustments satisfactory to the Owner.
 - d. Coordinate with the Owner for a list of access control cardholders and program the Access Control system with users and their required credentials.
 - e. Coordinate with the Owner for a list of intrusion alarm users and program the Intrusion Detection system appropriately.
 - f. Coordinate with the Owner and set up and program the Vape system according to their requirements.
 - g. Coordinate with the Owner and change default passwords on devices to passwords as required by the Owner.
 - h. Provide demonstrations of systems to the Owner and obtain written approval from the Owner of the installation and final programming of each system under the work of this Section.
 - 3. Testing of systems under the work of this Section.
 - 4. Training for systems under the work of this Section.
 - 5. Warranties of systems under the work of this Section.
 - 6. As-built documentation and Record drawings for systems under the work of this Section.
- B. UL 497 Primary and UL 497A secondary line lightning and Surge Protection:

1. Provide Surge and Lightning Protection for copper cabling run through underground PVC conduits.
 - C. Protection of new and existing work
 - D. Access panels and doors
 - E. Operation and Maintenance Instructions and Manuals for the Section's work
 - F. Training for systems under the work of this Section.
 - G. The Electrical Subcontractor shall remove and re-install ceiling tiles necessary for the work of this Section
 - H. Removal of trash from the site and cleanup of areas of work under this Section
 - I. Installation of devices on ceilings shall be coordinated with the Architect's reflected ceiling and lighting plan for the proper location of devices
 - J. Related Requirements
1. Premises Structured Data Cabling System shall be provided under Section 27 10 00.

1.5 RELATED SECTIONS

- A. Related Sections include the following:
 1. Section 26 00 00 "Electrical"
 2. Section 26 05 26 "Grounding and Bonding"
 3. Section 26 05 33 "Raceways and Boxes"
 4. Section 27 10 00 "Communications"
- B. Except for coordination, or unless otherwise indicated, the following work is not included as part of the Contractor's responsibilities in this Section and is to be performed by others as indicated:
 1. Power Requirements shall be provided by the Electrical Contractor.
 2. Costs associated with core drilling and cutting, and patching, using appropriate and trained tradesmen approved by the Construction Manager and the Engineer, shall be provided by the Electrical Contractor.
 3. Cutting and Patching shall be provided by Electrical Contractor.
 4. Sleeves for cable pathways shall be provided by the Electrical Contractor.
 5. Empty conduits to accessible points above the ceiling or below the floor shall be provided by the Electrical Contractor.
 6. Floor boxes and poke-through devices shall be provided by the Electrical Contractor.
 7. Standard device boxes with plaster rings for the Cabling Systems shall be provided by the Electrical Contractor.
 8. Structural blocking to support wall and ceiling-mounted equipment shall be provided by the Construction Manager.
 9. Fireproofing of Penetrations and Openings shall be provided by Electrical Contractor.
 10. Interface with public utilities telephone service will be arranged by the Owner's service provider and coordinated with this Section's Contractor.
 11. I-Loop and Wide Area Network outside the cabling plant will be provided by the Owner's service providers and coordinated with this Section's Contractor.
 12. The installation, operating cost, and maintenance of the controlled environmental conditions for equipment located on-site, as required by the manufacturer, NFPA 70B, or as specified in these specifications, shall be the responsibility of the Construction Manager.

1.6 SUBMITTALS

- A. Submit under the provisions of Division 01 Section "Submittal Procedures".

B. LEED Submittal – refer to Division 01 Sustainable Design Requirements.

1. LEED submittals are in addition to other submittals. If the submitted item is identical to that submitted to comply with other requirements, submit duplicate copies as a separate submittal to verify compliance with indicated LEED requirements.
2. Project Materials Cost Data: Provide a statement indicating the total cost for materials used for Project.
3. LEED Action Plans: Provide preliminary submittals indicating how the following requirements will be met:
 - a. Construction Waste Management: in compliance with Division 01 Section "Construction Waste Management."
 - b. List of proposed materials with recycled content: Manufacturer's certification of recycled content indicating percentage by weight of both pre-consumer and post-consumer recycled content.
 - c. Local/Regional Materials:
 - 1) Sourcing location(s): Indicate the location of extraction, harvesting, and recovery of raw materials used in the product's manufacturing; indicate the distance between extraction, harvesting, and recovery and the project site.
 - 2) Manufacturing location(s): Indicate the location of the manufacturing facility; include the distance between the manufacturing facility and the project site.

C. Submit within (30) days of Contract award and prior to installation of any materials or equipment complete shop drawings, product data, schedule of values, and qualification documentation to the Architect for approval review.

1. SUBMIT ALL ITEMS IN A SPECIFICATION SECTION AT THE SAME TIME. An incomplete submittal will be held until a complete submittal is accumulated or may be rejected without further review and returned to the applicable parties. .

D. Provide a Bill of Materials that clearly identifies the information requested herein for each and every item submitted. Include the Specification Paragraphs pertaining to each item submitted The Bill of Materials shall include the following "headings" in the order indicated from left-to-right on the Bill of Materials Index/Equipment List:

1. Item Number
2. Manufacturer's "Name" for each item
3. Manufacturer's "Model Number" for each item
4. Manufacturer's "Description" of each item
5. "Specification Section Number" reference the specification section number/location for the item submitted.

a. Example of Specification Section number/location: 2.13, B., 7., c., 4), e), page number

6. Bill of Material Header Example:

Item #.	Mfr. Name	Mfr. No.	Description	Spec Ref	Qty	Pg. No.
---------	-----------	----------	-------------	----------	-----	---------

7. All Bill of Material items shall be listed in the Bill of Material Index / Equipment List in the same order as they appear in the specification.
8. On each and every datasheet, indicate the applicable part numbers(s) on the sheet(s) by one of the following methods:

- a. Circling the applicable part number(s)
 - b. Putting an arrow next to the applicable part number(s)
 - c. Highlighting the applicable part number(s)
 9. Shop drawings shall include but not be limited to the following:
 - a. Built-in station arrangement.
 - b. Equipment cabinet arrangement.
 - c. One-line drawings.
 10. Include in the Submittal:
 - a. Qualification Data: For qualified Contractor.
 - b. Field quality-control reports.
 - c. Operation and Maintenance Data.
 - E. If the proposed equipment deviates from the Specifications or Drawings, indicate in writing on Company letterhead those differences and provide sufficient data to justify acceptance. FAILURE TO INDICATE DEVIATIONS OR SUBSTITUTIONS IMPLIES FULL COMPLIANCE WITH DRAWINGS AND SPECIFICATIONS.
 - F. It is intended that the Submittal be complete and accurate at the first submission.
 1. Submit all required Submittal information at one time.
 2. An incomplete Submittal shall be rejected in its entirety.
 - G. A minimum period of (15) working days, exclusive of transmittal time, will be required each time for review of a Submittal or Resubmittal. An additional (20) working days, exclusive of transmittal time, will be required for reviewing substitute materials or manufacturers. The review time period shall be considered by the Contractor when scheduling the work.
 - H. No equipment or material shall be used, furnished, or installed unless previously reviewed and accepted by the Architect.
 - I. Reviewed submittals on substitute equipment shall only allow the Contractor to proceed with installation. The substitution shall not be considered equal until such time as the Owner and Owner's Representative have completely accepted the installation. All costs for removal, relocation, or replacement of said Substitution shall be at the risk of the Contractor.
 - J. Regardless of any information included in the submittal submitted for review, the requirements of the Drawings and Specifications shall not be superseded in any way by the review. Review by the Architect does not relieve responsibility for submittal errors or for meeting the requirements of the Contract Documents.
- 1.7 SCHEDULE OF VALUES
- A. As part of the Submittal, provide a Schedule of Values with Unit Pricing to the Architect for approval review.
 - B. Schedule of Values
 1. Provide a schedule of values to be approved by Owner's representative, itemizing costs by construction phase for each technology system for labor and materials, with additional breakdowns for rough and finish work by construction phases, by system.

2. The schedule of values shall be submitted for review and acceptance prior to the payment of any invoice.
3. The schedule of values shall accurately reflect the actual costs for each category, including allocation for overhead and profit.
 - a. As a minimum, provide the following breakdown, by phase where applicable, as indicated:
 - 1.) Each major piece of equipment
 - 2.) Other equipment by category
 - 3.) Material and labor for each item.
 - 4.) Equipment installation by category and each major piece of equipment.
 - a.) Roughing work.
 - b.) Finish work.
 - 5.) Bond
 - 6.) Testing.
 - 7.) Owner training.
 - 8.) Operation and Maintenance Manuals.
 - 9.) Record drawings.

1.8 REGULATORY REFERENCES

- A. Comply with applicable requirements of the following standards and those others referenced in their SECTION.
- B. All work and materials shall conform in every detail to the rules and requirements of the National Fire Protection Association, the local Electrical Code, and present manufacturing standards.
- C. All materials shall be UL Listed and shall be marked as such. If UL has no published standards for a particular item, then other national independent testing standards shall apply, and such items shall bear those labels. Where UL has an applicable system listing and label, the entire system shall be so labeled
- D. All materials shall be ETL certified (not just tested).

1.9 QUALITY ASSURANCE

- A. Electrical Subcontractor Qualifications: Manufacturer's authorized representative who is trained and approved for installation of equipment required for the work of this Section.
 1. The Electrical Subcontractor (Firm and Employees) shall be experienced in the operations they are engaged to perform.
 2. The Electrical Subcontractor must provide documentation as part of the submittal process that they themselves are trained and authorized for the installation of the products specified.
 3. The Electrical Subcontractor must customarily furnish the size, scope, and nature of this Section and must be an authorized manufacturer's representative, certified (if certification programs exist with such manufacture), experienced, and qualified to provide, install, program, troubleshoot, train, warrant, and service the systems in this Section in their entirety.
 4. Provide documentation as part of the submittal process that the Electrical Subcontractor is authorized by the manufacturer(s) for products to be installed as part of this Section,

and is experienced and qualified to provide, install, program, troubleshoot, train, warrant, and service systems and products specified in this Section.

5. Provide documentation as part of the submittal process that the Electrical Subcontractor holds recent, up-to-date licenses and training certificates for the equipment to be installed.
6. The Electrical Subcontractor must provide as part of the submittal process a list of at least five (5) projects of similar size, scope, and nature.
 - a. Provide the following information for each project:
 - 1) Name of Project
 - 2) Address
 - 3) Contact Person, Title, and Telephone Number

- B. Testing Agency Qualifications: Qualified agency, with the experience and capability to conduct testing indicated.
- C. Comply with current TIA/EIA Building Telecommunications Wiring Standards and BICSI Telecommunications Distribution Methods and Standards.
- D. Comply with NFPA 70.

1.10 INTERPRETATION OF DRAWINGS

- A. All work indicated on the Drawings is intended to be approximately correct to scale, but figures, dimensions, and detailed Drawings are to be followed in every case. The Drawings shall be taken in a sense as diagrammatic. The size of raceways and methods of running them are indicated, but it is not intended to show every offset and fitting nor every structural difficulty that may be encountered.
- B. Locations indicated on the Drawings are approximate, and it is intended that all equipment shall be located in accordance with the general and detail Drawings of the construction proper. Refer to the Architectural drawings and coordinate the location, mounting heights, and routing of cabling work with other trades' requirements and with field conditions.
- C. All measurements shall be taken at the building before fabrication commences.
- D. Schematic diagrams shown on the Drawings indicate the required functions. Standard diagrams of the manufacturer may be used for the functions indicated without exact adherence to the Schematic Drawings shown. Work required for such deviations shall be provided.
- E. Items referred to in singular numbers in Contract Drawings shall be provided in quantities necessary to complete the work.
- F. The right is reserved to make reasonable changes in locations of work prior to rough-in at no additional cost.
- G. Where Drawings or Specifications conflict or are unclear, advise the Architect in writing before Award of Contract. Otherwise, interpretations of Contract Documents by the Architect shall be final, and no additional compensation shall be permitted due to discrepancies or ambiguities that are resolved according to the Architect's interpretation.

- H. Drawings and Specifications form complementary requirements. Provide work indicated on the Drawings, but not specified, and work specified, but not indicated on the Drawings as though explicitly required by both.
- I. Drawings and Specifications do not undertake to indicate every item required to produce a complete and properly operating installation. Materials, equipment, or labor that is not indicated, but that can be reasonably inferred to be necessary for a fully complete, secure, and properly operating installation suitable for the intended use shall be provided.
- J. Drawings do not limit the responsibility of determining the full extent of work required by Contract Documents. Refer to all Drawings and Specifications that indicate types of construction in which work shall be installed and work of other trades with which work of this Contract must be coordinated.
- K. Except where modified by a specific notation to the contrary, it shall be understood that the indication or description of any item in the Drawings or Specifications or both carries with it the instruction to provide the item, regardless of whether this instruction is explicitly stated as part of the indication or description.
- L. Where Drawings or Specifications do not coincide with the manufacturer's recommendations or with applicable Codes and Standards, alert the Architect in writing before installation. Otherwise, make changes in installed work as the Architect requires without additional cost.
- M. It is the intent of these Contract Documents to have systems and components that are fully complete and operational and fully suitable for the intended use. There may be situations in the documents where insufficient information exists to precisely describe a certain component or subsystem or the routing of a component. In such cases, where the Contractor has failed to notify the Architect in writing of the situation prior to Contract Award, the Contractor shall provide the specific component or subsystem with all parts necessary for the intended use, fully complete and operational, and installed in a workmanlike manner, either concealed or exposed per the design intent.
- N. In situations where potential conflict exists or where the Contractor believes guidance is required, submit a sketch identifying the proposed solution, and the Architect shall review, note if necessary, and return this sketch appropriately marked for use by the Contractor.

1.11 OBTAINING INFORMATION

- A. Obtain from the manufacturer the proper method of installation and connection of the equipment that is to be furnished or installed. Obtain all information that is necessary to facilitate the work and to complete the project. Include all such information in Operation and Maintenance Manuals.

1.12 PERMITS, FEES, RULES, AND REGULATIONS

- A. Give the proper Authorities all requisite notices or information relating to the work under this Contract. Obtain and pay for all fees, licenses, permits and certificates. Comply with the rules and regulations of all local, state, and federal authorities having jurisdiction, Building Codes, the rules and regulations of the National Board of Fire Underwriters, and the public utility companies serving the building.
- B. Public utility back charges will be paid for by the Owner and are not to be included in the base bid. Markups on utility back-charges will not be allowed.

- C. Perform work in accordance with Nationally Recognized Testing Laboratory (NRTL) listing or labeling requirements, OSHA regulations, NFPA Standards, Electrical Code, the Americans with Disabilities Act Accessibility Guidelines (ADAAG), TIA/EIA, and BICSI. The Drawings and Specifications do not attempt to indicate all work required by codes, regulations, and authorities.
- D. Nothing in these Contract Documents shall be construed to permit work not conforming to applicable codes and regulations. When conflicts occur, the more restrictive requirements shall govern.
- E. Toxicity: Comply with applicable codes and regulations regarding toxicity of combustion products used or hazardous materials used or disposed of.
- F. Legally dispose of all material. Adhere to all regulations regarding the disposal of hazardous material. Recycle hazardous material where recycling is possible. Submit certificates of legal recycling or disposal to the Architect. Include a copy in the Owner and Maintenance Manual.
- G. Should the Facility have established building standards, rules, or regulations, obtain a copy from the Building Owner, and comply with them.

1.13 PERFORMANCE REQUIREMENTS

- A. Materials and equipment shall be manufactured, installed, and certified as specified in the latest editions of applicable publications, standards, rulings, and determinations: The Electrical Subcontractor shall comply and reference the latest editions of the following standards included in a related addendum, or TSB's not listed below:
 - 1. ANSI/TIA/EIA 310D, Cabinets, Racks, Panels and Associated Equipment
 - 2. FCC Part 15 (addresses electromagnetic radiation).
 - 3. National Electrical Safety Code Handbook. (NESC)
 - 4. NFPA-70 – National Fire Protection Association (NFPA – 70)
 - 5. State and Local Building Codes.

1.14 DELIVERY, STORAGE, AND HANDLING:

- A. Do not deliver items to the site until specified submittals have been submitted to and approved by the Architect.
- B. Deliver materials in original packages, containers, or bundles bearing a brand name, or identification of manufacturer or supplier.
- C. Deliver, store, protect, and handle products in accordance with recommended practices listed in Manufacturer's Installation and Maintenance Manuals.
- D. Protect materials from damage due to moisture, direct sunlight, excessive temperatures, surface contamination, corrosion, and damage from construction operations and other causes.

1.15 SEQUENCING AND SCHEDULING

- A. Coordinate the work of this Section with the respective trades responsible for installing interface work and ensure that the work performed hereunder is acceptable to such trades for the installation of their work.

- B. Refer to the overall scheduling of the work of the project. Schedule work, process Submittal, and order materials and equipment to conform to this schedule, and install work to not delay nor interfere with the progress of the project.
- C. Inform Architect immediately of any delays or potential delays. Furnish the manufacturer's letter to verify order date, equipment delays, expected shipment date, order number, and potential remedies to speed up delivery. Any costs to speed up delivery shall be implemented at no cost to the project if the equipment or material was not ordered as soon as possible after the Contract award or within the time frames indicated with the Submittal.
- D. Include premium time required to comply with the project scheduling and phasing.
- E. Be aware of, and plan for project scheduling and phasing. Provide for complete continuous operation of all systems. Coordinate scheduling and phasing with the Architect, Owner, other Trades, and the Construction Manager.

1.16 WARRANTY

- A. Provide an installer's warranty for two (2) years against defects in material and workmanship on components, equipment, software, systems, and cabling specified. Warranty shall start at the time of substantial completion or routine use, whichever comes first. Warranty shall include materials, equipment, and work furnished or installed under this Section. Failure due to defective material, equipment, installation, or workmanship that may develop shall be corrected at no expense to the Owner, including materials, labor, travel, expenses, system diagnostics, and damage to areas, materials, and other systems resulting from such failures.
- B. Provide 3-year manufacturers' warranties for equipment furnished under this Section. Such warranties shall be in addition to, and not in lieu of, liabilities that the Manufacturer and the Installer may have by law or by provisions of the Contract Documents.

1.17 MAINTENANCE

- A. Upon receipt of notice from the Owner of the failure of any part of the systems during the warranty period, the affected parts shall be replaced at no cost. Any equipment requiring excessive service, consisting of more than two unscheduled service calls, shall be considered defective and shall be replaced
 - 1. Response times to warranty issues shall differ according to the level of the problem.
 - 2. A problem is considered to be corrected when the system and its components operate according to specified requirements.
 - 3. Warranty work shall be performed according to the procedures of the Owner, its staff and tenants, and their normal operations.
 - 4. The following levels of response to problems are required:
 - a. Major Failure: 4-hour maximum response time if notified by telephone, 24 hours per day, 365 days per year.
 - b. Minor Failure: 24 hours maximum response time if notified by telephone, 365 days per year.
 - 5. Failures are defined as follows:
 - a. Major Failure: a system failure that disables the entire system or major part of the system, or an individual critical piece of equipment that prevents the proper operation of more than one system component.

- b. Minor Failure: a system failure that affects only one non-critical component and does not affect the operation of any other components or any failure that is not defined as a major failure.
 - c. Major and minor failures are as defined by the Owner.
- 6. Response time to a call is defined as the time at which a qualified technician arrives at the site and starts repairs or diagnostics. If the problem has not been corrected within two hours of the initial response, regional and/or national support personnel shall be contacted for assistance.
- B. Adequate stocks of parts, components, and access to regional and national support personnel shall be available such that all major failures shall be corrected within 8 hours of the Owner's initial telephone call and all minor failures within 48 hours. Temporary components may be used to meet this requirement while new components or repairs are completed. Temporary components shall be replaced with new (unused) components or the original component repaired as soon as practical. Remanufactured equipment or components are not considered new and shall not be used.
- C. Provide certified factory-trained technical service personnel for service and maintenance of the system.
 - 1. Provide a copy of this warranty section in the Operations and Maintenance Manuals. Each copy shall be dated, signed, and certified by an authorized Representative of the Installer providing work under this Section stating that these requirements are understood and will be complied with without exception.

1.18 MAINTENANCE

- A. Upon receipt of notice from the Owner of a failure of any part of the systems during the warranty period, the affected parts shall be replaced. Any equipment requiring excessive service, consisting of more than two unscheduled service calls, shall be considered defective and shall be replaced.
 - 1. Response times to warranty issues shall differ according to the level of the problem.
 - 2. A problem is considered to be corrected when the system and its components operate according to specified requirements.
 - 3. Warranty work shall be performed according to the procedures of the Owner, its staff and tenants, and their normal operations.
 - 4. The following levels of response to problems are required:
 - a. Major Failure: 4-hour maximum response time if notified by telephone, 24 hours per day, 365 days per year.
 - b. Minor Failure: 24 hours maximum response time if notified by telephone, 365 days per year.
 - 5. Failures are defined as follows:
 - a. Major Failure: a system failure that disables the entire system or major part of the system, or an individual critical piece of equipment that prevents the proper operation of more than one system component.
 - b. Minor Failure: a system failure that affects only one non-critical component and does not affect operation of any other components or any failure that is not defined as a major failure.
 - c. Major and minor failures are as defined by the Owner.

6. Response time to a call is defined as the time at which a qualified technician arrives at the site and starts repairs or diagnostics. If the problem has not been corrected within two hours of the initial response, regional and/or national support personnel shall be contacted for assistance.
- B. Adequate stocks of parts, components, and access to regional and national support personnel shall be available such that all major failures shall be corrected within 8 hours of Owner's initial telephone call, and all minor failures within 48 hours. Temporary components may be used to meet this requirement while new components or repairs are completed. Temporary components shall be replaced with new (unused) components or the original component repaired as soon as practical. Remanufactured equipment or components are not considered new and shall not be used.
- C. Provide certified factory-trained technical service personnel for service and maintenance of the system.
 1. Provide a copy of this warranty section in the Operations and Maintenance Manuals. Each copy shall be dated, signed, and certified by an authorized Representative of the Installer providing work under this Section stating that these requirements are understood and will be complied with without exception.

1.19 RECORD DRAWINGS

- A. Submit Record Drawings for review with at least the minimum information, including "required linkages," "other linkages," and "user codes" required by TIA/EIA-606 for the following:
 1. Pathway Records
 2. Termination Hardware Records
 3. Space Records
 4. Termination Position Records
 5. Cable Records
 6. Grounding Records
 7. Labeling Records
- B. One complete set shall be maintained at the site on, which shall, at all times, accurately and clearly show the actual installations in accordance with the requirements of this SECTION.
- C. At the completion of the contract provide the following for approval.
- D. Complete set of "as-built" corrected Record Drawings.
 1. "As-built" drawings in hard copy and in electronic format with the following information.
 - a. All outlet locations identified
 - b. All identification labeling indicated for each outlet
 - c. All Sound equipment and locations identified
 - d. All Video equipment and locations identified
 - e. All Wire Closets and Racks identified
- E. Provide complete test reports for all systems.
- F. Provide all warranty information.

- G. "As-built" telecommunications drawings shall be submitted for approval prior to final inspection for acceptance of the work for each construction phase of the project.
- H. Approved "as-built" drawings shall be a prerequisite for scheduling any final inspection for acceptance of the work for this SECTION.

1.20 CERTIFICATES OF APPROVAL

- A. Upon completion of all work, and as a condition to receiving payment at Substantial Completion, furnish to the Architect the following original, signed certificates, and include copies of these certificates as part of the Operation and Maintenance manuals:
 - 1. Certification from the manufacturer's authorized representative stating that authorized factory engineers have inspected and tested the operation of their respective equipment and found same to be installed in accordance with the manufacturer's requirements, all requirements for manufacturer's warranties are complied with, and equipment is in satisfactory operating condition. This certification shall be provided for each piece of major equipment and for all complete systems. Provide a certificate for additional items requested by the Architect.
 - 2. Certificates of inspection, letters, or notices from the appropriate governmental authorized inspection authorities stating that all portions of the work (indicate trade and responsibility) have been inspected and are installed in conformance with the applicable codes, laws, ordinances, and referenced standards. If non-conformance notices are received, include the re-inspection certificate, and letter of explanation as required to indicate complete conformance. Provide written evidence of all exceptions or variances given by any Inspector.
 - 3. Certificate from the installing firm responsible for the work (indicate trade and responsibility) signed by an authorized Officer of the firm and the Foreman or Project Manager in charge, indicating trade license numbers and stating that to the best of the signer's knowledge and belief that the project (indicate project name and address) has been installed in compliance with the Contract Drawings, Specifications, and Addenda, and all applicable codes, laws, ordinances, and referenced standards. Where sub-contractors perform a portion of the work of this Section, include certificates from them.

1.21 SUBSTANTIAL AND FINAL COMPLETION

- A. Refer to General Conditions and Supplementary Conditions.
- B. Substantial Completion shall not be considered unless all systems are tested and verified for adherence with Contract Documents and any work remaining is less than one percent of the total Contract Value of this Section.
 - 1. Record Drawings, Operation and Maintenance Manuals, Acceptance Demonstrations, Owner personnel training, spare parts or extra materials required, test reports, warranties, and certifications of installation inspections shall be submitted and accepted prior to Substantial Completion.
- C. Final Completion shall be when all work under this Section is completed as defined by the Contract Documents and accepted by the Architect.
- D. Upon completion of all work under this Section, submit written certifications that:
 - 1. Contract Documents, including addenda, clarifications, change orders, RFIs, and instructions from Architect, have been reviewed.

2. Work has been inspected for compliance with Contract Documents.
3. Work has been completed in accordance with Contract Documents, and any deficiencies listed with the Certificate of Substantial Completion have been corrected.
4. Equipment and systems are fully operational.
5. Work is complete and ready for Architect's final review.

E. When Architect determines Work is complete, close-out submittals will be considered.

1.22 OPERATING INSTRUCTIONS AND MAINTENANCE MANUALS

- A. At least (30) days prior to Substantial Completion, submit for review three sets of Operating and Maintenance Manuals containing Manufacturer's catalogs, and other similar data, including the necessary photographic equipment cuts, wiring diagrams, and final reviewed Shop Drawings and Product Data covering all equipment and devices furnished or installed under this Section. These manuals shall provide complete instructions for the proper operation and use of the equipment, together with instructions for lubrication and periodic maintenance and troubleshooting. Operating instructions shall be specific for each system and shall include copies of posted specific instructions. This manual shall contain only information that specifically applies to this project, and all unrelated material shall be deleted or clearly crossed out.
- B. The Owner and Maintenance Manual material shall be bound in 3-ring binders and indexed.
1. On the edge of the binder provide a clear see-through plastic holder with a typed card indicating the Project name, the Architect's name, the installer's name, and the Volume number (e.g., Vol. No. 1 of 2).
 2. The index shall identify the page number(s) or section divider number for each item.
 3. The Owner and Maintenance Manual Index column headings shall identify the following minimum information. Manuals must be submitted using the following "headings" in the order indicated from left to right on the Index:
 - a. "Description" of each item
 - b. "Manufacturer's" Name for each item
 - c. Manufacturer's "Model #" for each item
 - d. Owner and Maintenance Manual "Page" Number(s) or "Section" Divider Number for each item.
- C. Provide the name, address, and telephone number of the manufacturer's representative and service company for all items supplied so that the source of replacement parts and service can be readily obtained.
1. Include copies of the manufacturer's and installer's warranties and maintenance contracts, and performance bonds properly executed and signed by an authorized representative.
- D. Include copies of all test reports and certifications.
- E. Include copies of all Warranties.

1.23 EXTRA MATERIALS

- A. Furnish extra materials described below that match the products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Intrusion Detection Devices: Furnish quantity equal to five percent of the number of units of each type installed, but no fewer than one of each type.
2. Fuses: Three of each kind and size.
3. Tool Kit: Provide six sets of tools for use with security fasteners, each packaged in a compartmented kit configured for easy handling and storage.
4. Security Fasteners: Furnish no fewer than one box for every 50 boxes, or fraction thereof, of each type and size of security fastener installed.

1.02 SEISMIC REQUIREMENTS

- A. Equipment and work shall meet the restraint requirements for a Seismic Zone - 2 location, including installation and connections of material and equipment to the building structure.

PART 2 - PRODUCTS

2.01 INTEGRATED ELECTRONIC SECURITY SYSTEM MANUFACTURERS

- A. The Awarding Authority has determined that no substitutions shall be permitted. Single Source: Access Control and CCTV Video Surveillance, and Intrusion Detection under this Section shall be provided by the following manufactures.

1. Genetec Security Center
2. Genetec Security Center
3. Axis CCTV cameras
4. Bosch Digital Intrusion Alarm Controller

2.02 CCTV NETWORK VIDEO MANAGEMENT SYSTEM

- A. Network Video Management Systems (NVMS). Provide products from Genetec meeting the requirements of the Drawings and Specifications as follows, or approved equal
1. Provide Genetec 64TB server, part number SV-4020E(X)-R14, or approved equal
Network Connection: 10 GbE - with multiple network connections
Recording Data Rate: Up to 1500 Mbps (max 1250 Mbps per connection)
Playback and Live Streaming: Up to 600 Mbps (while simultaneously recording video)
Recording Storage Capacity: Up to 180 TB raw, 157 TB effective (RAID 6), or 252 TB raw, 192 TB effective (RAID 60)
Hard Disk Drive Configuration: Video data — up to 18 x large form factor near-line SAS hard disk drives, hot-swappable, RAID 6 or RAID 60 Operating system — 2 x M.2 SSD drives, RAID 1
Network Interface: 2 x 10 GbE SFP+ ports (transceivers not included) 2 x 1 GbE RJ-45 ports (1000Base-T)
Memory: 32GB DDR4
Operating System: Microsoft Windows Server 2016
Processor: Intel® Xeon®
Video Outputs: VGA
Out-of-band management: iDRAC9 Express
Form Factor: 2U rack mount chassis
Power Input: 100 to 240 VAC, 50/60 Hz, auto-switching
Power Supply: 80 Plus rating redundant, hot-swappable
Power Consumption: Average: 429 W (1+1) (1463.8 BTU/h), Maximum: 750 W (2559.1 BTU/h)
Certifications: UL, cUL, CE, BIS, BSMI, CCC, EAC, KC, NOM, NRCS, VCCI, RCM
Safety: EN 60950-1:2006 / A11:2009 / A1:2010 / A12:2011 / A2:2013; UL/CSA/IEC 60950-1, 2 Ed + Am 1: 2009 + Am 2: 2013
Electromagnetic Emissions: US CFR Title 47, FCC Part 2, 15; Canadian ICES-003(A) Issue 6; EN 55032:2012/ EN 55032:2015/ CISPR 32:2012/ CISPR 32:2015 (Class A); EN 61000-3-2:2014/ IEC 61000-3-2:2014 (Class D); EN 61000-3-3:2013/ IEC 61000-3-3:2013
Electromagnetic Immunity: EN 55024:2010+A1:2015/CISPR 24:2010 + A1:2015
Energy: Commission Regulation (EU) No. 617/2013
ROHS: EN 50581:2012
 2. Provide Enterprise client and server software pre-installed with 3-year software updates.
- B. Installer shall be responsible for providing the proper quantity of Network Video Recorders and equipment based on proper calculations for bandwidth and storage requirements. Image

storage requirements shall be 30 days based on 17 FPS minimum and 12 hours recording on motion for each camera. Provide Network Video Recorder equipment.

1. Camera Licenses (required quantities)

C. High Performance Remote Monitoring Workstation

1. Provide an Genetec professional high-performance remote monitoring workstation for up to 4 monitors, part # SVW-500E with 3-year warranty, or approved equal.

Display:

4 × 1080p: 60 Hz max refresh rate (via mini DisplayPort or HDMI)

4 × 4K: 60 Hz max refresh rate (via mini DisplayPort only)

Viewing Streams: Up to 64

Performance (using 4 x 1080p displays):

Operating System: Microsoft Windows 10 IoT Enterprise LTSB

Processor: Intel® Core™ i7

Memory: 8 GB DDR4 RAM

Network Interface: 2 Gigabit Ethernet RJ-45 ports (1000Base-T)

Video Outputs: 4 active (4 × mDP)

Optical Drive: DVD-RW

Supported Monitor Interfaces: Up to 4 combinations of mDP and/or HDMI (with supplied accessories) USB Keyboard, USB Mouse, Power cord, 4 mini-DisplayPort (mDP) to DVI adapters

D. UPS Systems

1. SMT3000RM2U UPS, or approved equal. (Provide – 1 for each Video Recorder)
2. WBEXTWAR3YR-SP-04 3-Year Extended Warranty, or approved equal. (PROVIDE – 1 for each UPS system installed)

E. Rack Mounted LCD Console (PROVIDE – 1)

1. Manufacturer: APC, Part # AP5719, or approved equal.
 - a. Specifications
LCD Monitor shall occupy 1 rack space.
Overall dimensions shall be 1.73 in. H x 19 in. W x 26.18 in. D.
LCD display size shall be 19 in. diagonal
TFT active matrix screen
USB port supports USB pass-through
Power tilt sensor to turn off monitors power when closed for energy efficiency
Integrated touchpad
Embedded Menu system
Allows for Rear Mounting of a KVM Switch in the same rack space

F. Provide Accessories as follows.

1. APC KVM 2G Digital/IP 16-port KVM switch Part # KVM1116P, or approved equal. (PROVIDE – 1)
2. APC Extended Warranty, Part # AP5610, or approved equal. (PROVIDE – 1)

2.03 CCTV IP CAMERAS

- A. Manufacturers: Arecont, Avigilon, Axis, or approved equal
 - 1. Provide CCTV IP Cameras with the features listed below. All CCTV cameras shall be from a single source. (Provide quantity as indicated on the drawings)
- B. Interior/Indoor Dome Cameras
 - 1. Minimum Key Features
 - 1-5 megapixel and 4K Ultra HD (8 MP) resolution
 - Patented Advanced Video Pattern Detection and Teach by Example Technology
 - Self-learning video analytics
 - Patented High Definition Stream Management (HDSM)™ Technology
 - Wi-Fi camera configuration support
 - Available with 3-9 mm F1.3, 4.3-8 mm F1.8, or 9-22 mm F1.6 P-Iris lens with remote focus and zoom
 - Zoom and content adaptive integrated IR (Infrared) LEDs provide uniform illumination in the dark, even at 0 lux, up to a maximum of 30 m (98 ft) away
 - Exceptional image quality in low light environments (1-5 MP models)
 - Triple Exposure Ultra-Wide Dynamic Range (1-3 MP models)
 - ONVIF compliant with version 2.2.0 of the Analytics Service Specification
 - Full Feature or High Framerate camera operating modes (4K Ultra HD model)
 - Vandal resistant construction
- C. Exterior/Outdoor Dome Cameras
 - 1. Minimum Key Features
 - 1-5 megapixel and 4K Ultra HD (8 MP) resolution
 - Patented Advanced Video Pattern Detection and Teach by Example Technology
 - Self-learning video analytics
 - High-Definition Stream Management Technology
 - Available with 3-9 mm F1.3, 4.3-8 mm F1.8, or 9-22 mm F1.6 P-Iris lens with remote focus and zoom
 - WiFi camera configuration support
 - Zoom and content adaptive integrated IR (Infrared) LEDs to provide uniform illumination in the dark, even at 0 lux, up to a maximum of 30 m (98 ft) away
 - Ability to capture images with exceptional image quality in extreme low light environments
 - Triple Exposure Ultra-Wide Dynamic Range (1-3 MP models)
 - ONVIF compliant with version 2.2.0 of the Analytics Service Specification
 - Vandal resistant construction and IP66 compliant
 - Full Feature or High Framerate camera operating modes (4K Ultra HD model)
 - 2. Accessories
 - a. Wall Mount
 - b. Pendant Mount
 - c. Pole Mount
- D. Exterior/Outdoor Bullet Cameras
 - 1. Minimum Key Features
 - 1-5 megapixel and 4K Ultra HD (8 MP) resolution

Patented Advanced Video Pattern Detection and Teach by Example Technology
Self-learning video analytics
High-Definition Stream Management Technology
Available with 3-9 mm F1.3, 4.3-8 mm F1.8, or 9-22 mm F1.6 P-Iris lens with remote focus and zoom
WiFi camera configuration support
Zoom and content adaptive integrated IR (Infrared) LEDs provide uniform illumination in the dark, even at 0 lux, up to a maximum of 30 m (98 ft) away
Ability to capture images with exceptional image quality in extreme low light environments
Triple Exposure Ultra-Wide Dynamic Range (1-3 MP models)
ONVIF compliant with version 2.2.0 of the Analytics Service Specification
Integrated IR (Infrared) LEDs to provide uniform illumination in the dark, even at 0 lux, up to maximum of 70 m (230 ft) away
Factory pre-configured Image preset modes for maximum image performance in a variety of lighting conditions
Vandal resistant construction and IP66 compliant
Full Feature or High Framerate camera operating modes (4K Ultra HD model)

2. Accessories

- a. Wall Junction Box
- b. Pole Mount

E. Exterior/Outdoor CCTV PTZ Cameras

1. Minimum Key Features

2 MP camera resolution
zooms up to 30x
Self-learning video analytics
Advanced Video Pattern Detection and Teach by Example Technology
High Definition Stream Management (HDSM) technology
Ability to capture images with exceptional image quality in extreme lowlight environments
Up to 60 fps high frame rate operation
IP67 certified for comprehensive dust and water ingress protection
True wide dynamic range (WDR)

2. Accessories

- a. Pole Mount

F. Multi-sensor Cameras

1. Key Features

3-Sensor Cameras: 3 x 3 MP (9 MP), 3 x 5 MP (15 MP), 3 x 8 MP (24 MP) 1/3"
Progressive scan sensor
4-Sensor Cameras: 4 x 3 MP (12 MP), 4 x 5 MP (20 MP), 4 x 8 MP (32 MP) 1/3"
Progressive scan sensor
Each lens 2.8-8mm remote zoom and focus lens
H.264 and Motion JPEG compression
100dB Wide Dynamic Range performance
ONVIF compliant API
Automatic exposure control and iris control
Automatic removable IR cut filter for IR sensitivity at night

Power over Ethernet, 24 VAC or 24 VDC power input
External microphone and speaker support for two-way audio
External I/O interface for connecting alarms and relays
Supports broad environmental conditions for challenging outdoor installations

2. Accessories

- a. Wall Mount
- b. Pendant Wall Mount
- c. Pole Mounting Bracket

G. Accessories

1. Provide all required accessories
2. Verify with the Owner if clear or smoke covers are required prior to ordering.

H. Install CCTV cameras according to manufacturer's specifications. Coordinate with Owner for camera parameters and review each camera setup with the Owner.

2.04 INTEGRATED ACCESS CONTROL SERVER

A. Provide Genetec 64TB server, part number SV-4020E(X)-R14, or approved equal

2.05 ACCESS CONTROL PANELS

A. Provide Mercury Security controllers, or approved equal (Provide quantity as indicated on the drawings).

2.06 ACCESS CONTROL FIELD HARDWARE DEVICES

A. Proximity/Card Readers

1. Provide HID mullion Proximity Card Readers, part # AC-HID-READ-ICLASS-SE-R10-AVG, or approved equal (Provide quantity as indicated on the drawings)
 - a. Proximity/Card Reader shall be certified and approved by Access Control manufacturer for compatibility with the Access Control System.
2. HID iCLASS SE Cards or Key Fobs, or approved equal. (Provide – 500)
 - a. HID Cards and Key fobs shall be certified and approved by the Proximity Card Reader manufacturer for compatibility with their Proximity Card Reader.
 - b. Coordinate with the Owner to determine whether Cards or Key Fobs are desired prior to ordering.

2.07 WIRELESS ENTRY ALERT DOOR CHIMES

A. Provide a wireless battery-operated Bell-4000rd entry alert door chime system from EntryBell (EntryBell.com) or approved equal at the vocational shop corridor doors indicated on the drawings with "WC" and "CH" symbols.

1. Provide (2) wireless receivers, (1) placed in shop office and (1) placed at a location determined by the shop instructors.

B. The systems shall include the following.

1. Wireless magnetic door sensors (contacts)
 2. Wireless 120V plugin receiver
- C. The systems shall have a minimum of 1,000 ft range.
- D. The system wireless receivers shall have multiple selectable chimes and volume levels from 75db up to 105Db.
- E. The systems shall have a low battery alert.
- F. The receiver alerts shall be simultaneous light and sound alerts when doors are opened.
- G. The systems shall be expandable to 16 sensors and one receiver
- H. The system shall be ETL Listed. FCC certified. And UL/cUL Listed.
- I. Installation
1. Install door sensors (contacts) on door frames with screws.
 2. Plug the receivers into a 120V receptacles in office areas.
 3. Set the receiver at 105db for the chime (tone).
- J. Training
1. Train the vocational shop instructors on the setup, operation. and maintenance of the systems.

2.08 DIGITAL INTRUSION DETECTION SYSTEM

- A. Provide Bosch D9412GV2 Digital Alarm Communicator Control Panel, or approved equal.
- B. The Electrical Subcontractor shall provide, install, and program a functionally complete, integrated Digital Alarm Communicator and Access Control System (DACS) per Manufacturer's guidelines, codes described, within these specifications.
1. Digital Alarm Communicator shall be certified and approved by Access Control manufacturer for compatibility with the Access Control System.
 - a. The DACS shall be provided, at minimum, with the following components.
 - Enclosure
 - Lock and key
 - D9412GV2 DACT with removable terminal blocks and single screw mounting bracket
 - Faceplate shield and metal bracket covering rear of D9412GV2 circuit assembly
 - Power transformer
 - f. Manuals
- C. The Electrical Subcontractor shall program a functionally complete, integrated Digital Alarm Communicator System (DACS) as follows.
1. Coordinate with the Owner for the following.
 - a. Setup of required zones

- b. Arming/disarming requirements
- c. Import of all required users
- d. Required monitoring service

D. Intrusion Alarm/Integrated Digital Alarm Communicator Specifications

1. Control Panel - The control panel shall be an eight (8)-partition, UL commercial burglary control panel that supports up to 250 zones using basic hardwired, polling loop, and wireless zones. It shall also provide supervision of the bell output, RF receivers, and relay modules. In addition, the controller shall provide the ability to schedule time-driven events and allow certain operations to be automated by pressing a single button. The system shall be capable of interfacing with an ECP long-range radio (LRR) unit that can send Contact ID messages and alphanumeric paging devices. The control shall provide integrated access control and CCTV-switching capability.
2. Basic Hardwired Zones - The control shall provide nine (9) style-B hardwire zones with the following characteristics:
 - a. EOLR supervision (optional for zones 2-8): Shall support N.O. or N.C. sensors (EOLR supervision required for UL installations).
 - b. Individually assignable to one of eight (8) partitions.
 - c. Support up to 16 two-wire smoke detectors in one selected zone.
 - d. Support four-wire smoke or heat detectors on any zone (power to four-wire smoke detectors must be supervised with an EOL device)
 - e. Support up to 50 two-wire latching glass break detectors on one selected zone.
3. Optional Expansion Zones
 - a. Polling Loop Expansion – The control shall support up to 241 additional hardwire zones using a built-in two-wire polling (multiplex) loop interface. The polling loop shall provide power and data to remote point modules and constantly monitor the status of all zones on the loop. The maximum current draw shall not exceed 128 mA. The polling loop zones shall have the following characteristics:
 - b. Interface with RPM (Remote Point Module) devices that provide Class B, Style Y (e.g., 4208U/4208SN) or a combination of Class B, Style Y, and Class A, Style Z (e.g., 4208SNF) zones.
 - c. Individually assignable to one of eight (8) partitions.
 - d. Supervised by the control panel.
 - e. A 12,000 ft (3658 m) wire run capability without using
 - f. shielded cable.
 - g. Each RPM (Remote Point Module) enclosure shall be tamper protected.
4. Partitions – The control shall provide the ability to operate eight (8) separate areas, each functioning as if it had its own control. Partitioning features shall include:
 - a. A Common Lobby partition (1-8), which can be programmed to perform the following functions:
 - i. Arm automatically when the last partition that shares the common lobby is armed.
 - ii. Disarm when the first partition that shares the common lobby is disarmed.
 - b. A Master partition (9) is used strictly to assign keypads for the purpose of viewing the status of all eight (8) partitions at the same time (master keypads).

- c. Assignable by zone.
 - d. Assignable by keypad.
 - e. Assignable by relay to one or all eight (8) partitions.
 - f. Ability to display fire and/or burglary and panic and/or trouble conditions at all other partitions' keypads (selectable option).
 - g. Certain system options selectable by partition, such as entry/exit delay and subscriber account number.
5. User Codes – The control shall accommodate 250 user codes, all of which can operate any or all partitions. Certain characteristics must be assignable to each user code, as follows:
- a. Authority level (Master, Manager, or several other Operator levels). Each User Code (other than the installer code) shall be capable of being assigned the same or a different level of authority for each partition that it will operate.
 - b. Opening/Closing central station reporting option.
 - c. Specific partitions that the code can operate.
 - d. Global arming capability (ability to arm all partitions the code has access to in one command).
 - e. Use of an RF (button) to arm and disarm the system (RF key must first be enrolled into the system).
 - f. Peripheral Devices – The control shall support up to 30 addressable ECP devices, which can be any combination of keypads, RF receivers, relay modules, annunciator modules, and interactive phone modules. Peripheral devices have the following characteristics:
 - i. Each device is set to an individual address according to the device's instructions.
 - ii. Each device enabled in system programming
 - iii. Each device's address shall be supervisable (via a programming option).
6. Keypad/Annunciator – The control shall accommodate up to 16 keypads or six (6) touchscreen (i.e.; advanced user interface) keypads. The keypads shall be capable of the following:
- a. Performing all system arming functions.
 - b. Being assigned to any partition.
 - c. Providing four programmable single-button function keys, which can be used for:
 - i. Panic Functions –activated by wired and wireless keypads; reported separately by partition.
 - ii. Keypad Macros –32 keypad macro commands per system (each macro is a series of keypad commands). Assignable to the A, B, C, and D keys by partition.
7. Integrated Access Control – The control shall be capable of the following:
- a. Providing a command that activates relays to allow access doors to open (e.g., lobby door), lights to be turned on or off.
 - b. Becoming a fully integrated access control system by using numerous VistaKey Single-Door Access Control Modules.
 - c. Supporting up to 15 VistaKey Access Control Modules. The VistaKey Access Control Modules shall use the same Compass Downloader as the Vista-250BP

- and shall be programmable from the Compass Downloader or the Keypad/Annunciators.
 - d. Assigning any number of access control relays to each partition (up to 96 for the system).
 - e. Supporting up to 500 access card holders using VistaKey.
8. Voltage Triggers – The system shall provide voltage triggers, which change state for different conditions. Used with LRR (Long Range Radio) equipment or other devices such as a remote keypad sounder, keyswitch ARMED and READY LEDs, or a printer to print the system's event log.
9. Event Log – The System shall maintain a log of different event types (enabled in programming). The event log shall provide the following characteristics:
- a. Stores up to 1,000 events.
 - b. Viewable at the keypad or through the use of Compass software.
 - c. Printable on a serial printer using a 4100SM Module including zone alpha descriptors.
 - d. Stores PassPoint access control events.
 - e. Sends printed events to up to eight (8) alphanumeric pagers.
10. Panel Linking - The Control shall be capable of being networked together with up to eight other controls and being operated by any keypad within the system. It shall provide the ability for users to:
- a. Control multiple zones, partitions, and/or buildings from a central location.
 - b. Check status, arm and disarm any partition from any keypad in the system.
 - c. Globally arm or disarm partitions based upon user authority.
11. Automation Software - The Control shall be capable of interfacing with automation software via an RS232 input on a single partition.
12. Enclosure
- a. A. The Control Panel shall be enclosed in a metal cabinet, suitable for wall mounting.
 - b. The dimensions shall not exceed 14.5 inches (36.8 cm) in height, 12.5 inches (31.8 cm) in width or 3 inches (7.6 cm) in depth.
13. Electrical Power Requirements
- a. System Power – The Fire and Burglary Alarm System shall operate using standard 120 volts AC, 50/60 Hz power.
 - i. Control Primary Power – Transformer power shall be 16.5 VAC, 40VA.
 - ii. Backup Battery – A rechargeable 12 VDC, gel type, lead acid backup battery shall be provided. The battery shall be rated between 7 and 34-ampere hours (AH).
 - iii. Alarm Power – Alarm power shall be 10 - 13.8 VDC, 1.7 amps for each bell output
 - iv. Auxiliary Standby Power – Standby power shall be 9.6 - 13.8 VDC, 750 mA maximum.
 - v. Fusing – The battery input, auxiliary, and bell outputs shall be protected using PTC circuit breakers. All outputs shall be power limited.
14. Environmental Conditions

- a. Environmental Conditions – The Fire and Burglary Alarm System shall be designed to meet the following environmental conditions.
 - i. Storage Temperature – The system shall be designed for a storage temperature of -10° C to 70°C (14° F to 158°F).
 - ii. Operating Temperature - The system shall be designed for an operating temperature of 0° C to 50°C (32° F to 120°F).
 - iii. Humidity - The system shall be designed for normal operation in an 85% relative humidity environment.
 - iv. Electromagnetic Interference – The system shall meet or exceed the requirements of FCC Part 15, Class B devices, FCC Part 68, IEC EMC directive.
- 15. Telephone Lines, IP Addresses, and "Phone Routing": The DACS shall support one or two telephone lines that are to be alternated for the transmission of consecutive events. The DACS shall have the capability of communicating with up to eight (8) different DACRs (4 different phone numbers) and/or four (4) different IP Addresses. Each Phone Number can be up to 24 digits long.

2.09 ACCESSORIES

- A. Bosch Part #D1260 Intrusion Keypads, or approved equal. (Provide quantity as indicated on the drawings).
 - Power Requirements
 - Voltage: Nominal 12 VDC
 - Standby Current: Idle 200 mA Maximum 250 mA, with the sounder and display backlight at maximum
 - Keypad
 - Dimensions: 10.9 cm x 20 cm x 2.6 cm (4.3 in. x 7.9 in. x 1 in.)
 - Weight: 439 g (15.5 oz.)
 - Indicators: Illuminated keys Warning and indicating tones
 - Material: GE CYCOLOY C1110. UL94 HB Fire Rated
 - Connections: 4-wire flying lead for data and power
 - Resistance: 14 Ω maximum
 - Display Screen
 - Type: Backlit LCD
 - Size: 8.6 cm x 3.6 cm (3.4 in. x 1.4 in.)
 - 4 lines x 20 characters
 - Environmental Considerations
 - Humidity: 95% \pm 2% at +49°C (+120°F)
 - Operating Temperature: 0°C to +49°C (+32°F to +120°F)
 - Number of Keypads per Control Panel:
 - 8 supervised 32 unsupervised
- B. Bosch Part #DS778 Long Range PIR Detectors, or approved equal. (Provide quantity as indicated on the drawings)
- C. Bosch Part #DS306E Motion PIR Detectors, or approved equal. (Provide quantity as indicated on the drawings)
- D. Indoor Piezo Siren: ADEMCO WAVE 2EX, or approved equal. (Provide quantity as indicated on the drawings).
 - Current Draw/High Output – 110 mA @24 VDC
 - Current Draw/Low Output – 60 mA @ 12 VDC

Sound Pressure Output
106 db @ 1 meter (high output)
100 db @ 1 meter (low output)

- E. Cooper Wheelock RSSWP (Weatherproof) 24V Beacon/Strobe, or approved equal. (Provide quantity as indicated on the drawings).
- F. Switching Power Supply Charger: Altronix AL600ULB, or approved equal. (Provide quantity as indicated on the drawings).
12VDC or 24VDC selectable output.
6 amp supply current.
Non-power limited output. Sealed lead-acid battery, 18 Ah. D1218
Transformer, 16.5 VAC, 40 VA. D1640
Input: 28VAC / 200VA
Filtered and electronically regulated outputs.
Short circuit and thermal overload protection.
Built-in charger for sealed lead acid or gel type batteries.
Maximum charge current:: .7 amp.
Automatic switch over to stand-by battery when AC fails (zero voltage drop).
AC fail supervision (form "C" contacts).
Low battery supervision (form "C" contacts).
Battery presence supervision (form "C" contacts).
AC input and DC output LED indicators.
- G. Rechargeable Sealed Lead-Acid Battery: PowerSonic PS-1270 12 Volt 7.0 Amp. Hrs, or approved equal, (Provide quantity as indicated on the drawings).
Nominal Voltage: 12 volts (6 cells in series)
Nominal Capacity:
20 hour rate (350mA to 10.50 volts): 7.0 A.H.
10 hour rate (650mA to 10.50 volts): 6.5 A.H.
5 hour rate (1.2A to 10.20 volts): 6.0 A.H.
1 hour rate (4.5A to 9.00 volts): 4.5 A.H.
15 min rate (14A to 9.00 volts): 3.5 A.H.

2.10 CABLING

- A. Provide and terminate all cabling required for a completely operational Intrusion Alarm System between field devices and Intrusion Alarm System Headend, as recommended by equipment manufacturer.
- B. Backboxes with conduit stubbed above accessible ceilings shall be provided by the Electrical Subcontractor.
- C. At all back-box locations, cables shall have a minimum 18 in. service loop coiled in back box.
 - 1. Cabling and equipment shall be configured to provide addressable devices at all locations.
- D. Key Pad: The control station shall be connected to the control/communicator with #22 AWG, shielded, six-wire cable, and have a maximum of 1,000 ft. between the control/communicator and the control station.
- E. Motion Sensors: Provide a minimum #22-AWG, six-conductor unshielded cable.

- F. Door Contacts: provide a minimum #22-AWG, four-conductor cable.
- G. Multiplex Loops: Used for Motion Sensor, Door Contacts, Glass Break Detectors. Provide #22 AWG six-conductor cable for loops up to 2,000 ft. Provide #18 AWG six-conductor cable for loops up to 5,000 ft. Do not use twisted-pair or shielded cable for multiplex bus wiring loops. Cable shall be as recommended by the equipment supplier.
- H. Proximity/Card Readers and Request-to-Exit Sensors: Provide minimum 18-AWG, five-conductor shielded cable.
- I. Request-to-Exit Sensors: Provide minimum 18-AWG, four-conductor shielded cable.

2.11 MONITORING SERVICE

- A. Monitoring Service Contract: Include a 3-Year Off-site Central Station Monitoring Service Contract in the bid price.
 - 1. Monitoring Service Company shall be of Owner's choice.

2.12 DOOR AUDIO / VIDEO INTERCOM SYSTEM

- A. All doors to the school proper shall remain locked during the course of the school day. Access to the building shall be via doors indicated on the Drawings. School personnel shall use an audio/video intercom at the designated doors to challenge persons who wish to access the school during regular school hours before remotely releasing the exterior door lock as well as the inner vestibule door lock. Releasing the exterior and inner vestibule door locks shall be separate operations.
- B. Manufacturer: Subject to compliance with requirements, provide products by one of the following manufacturers, or approved equal
 - 1. Aiphone IX and IXG series, TOA SIP Intercom Station N-SP80 Series, Alpha Communications IPPLUS series, or approved equal
- C. Basis of Design: Aiphone IX Series capable of working on an IP network.
 - 1. System shall provide communications to selected entry doors, giving the operator the capability of not only talking with and observing the person requesting entry into the building, but also remotely releasing the door.
 - 2. Provide all active equipment, final connection, and programming for the door audio / video intercom system.
 - 3. Horizontal data premises cabling shall be provided under Section 27 10 00.
- D. Part Numbers.
 - 1. Aiphone part # IX-MV7 - Video Master Station for IX Series (802.3af PoE compliant), or approved equal),
 - 2. Aiphone part # IX-DF - IP Video Door Station for IX Series, Flush Mount, Stainless Steel (802.3af PoE compliant), or approved equal.
 - 3. Aiphone part # IX-SS – 2G Audio Only Door Station for IX Series, Flush Mount, Stainless Steel (802.3af PoE compliant), or approved equal.
 - 4. Aiphone part # RY-IP44 IP based programmable relay adaptor with PS-1225UL power supply, or approved equals.

5. Aiphone part # IXG-DM7-HID IP Video Entrance Station with HID Reader), or approved equal.
6. Aiphone part # IXG-DM7-BOX Flush Mount Back Box for IXG-DM7-HID), or approved equal.
7. Aiphone part # SBX-IXGDM7 Stainless Steel Surface Mount Box for IXG-DM7-HID), or approved equal.
8. Aiphone part # IXG-2C7 IP Video Tenant Station with 7" Touchscreen), or approved equal.
9. Aiphone part # IXGW-GW IXG Series Mobile App Gateway), or approved equal.
10. Aiphone part # IX-DV IP Video Door Station, SIP Compatible, Vandal Resistant, Surface Mount, Aluminum Die Cast Cover), or approved equal.
11. Aiphone part # IX-SS-2G IP Audio 2-Gang Door Station, SIP Compatible, Vandal Resistant, Stainless Steel), or approved equal.
12. IX Mobile App - Mobile App Sub Master Station for Smartphones and Tablets), or approved equal.

E. Color Monitor Master Station:

1. Product: Color monitor IP master station (IX-MV7).
 - a. Power Source: 802.3af PoE
 - b. Communication:
 - i. Handset Simultaneous Communication
 - ii. Hands-free Auto-voice actuation or
 - iii. PTT (push-to-talk)
 - c. Monitor: 3.5-inch (89 mm) color LCD monitor.
 - d. Brightness control.
 - e. 6 programmable speed dial buttons for calling stations or accessing paging zones.
 - f. Paging Capacity: Simultaneous paging to Maximum 5 zones/stations.
 - g. Mounting: Desktop use, with stand.
 - h. Ambient Temperature: 0 - 40 degrees C (+32 degrees F - +104 degrees F).
 - i. Dimensions: 7-7/16" H x 9-13/16" W x 2-5/16" D.
 - j. Electrical Box: 3 gang box, for wiring and fixing the unit.
 - k. Material: Flame resisting ABS resin.
 - l. Color: Black
2. Symbol Type VMS: Audio / Video Master Station
 - a. One (1) RJ-45, Cat. 6E, 8-position connector for data cabled to data patch panel in nearest wire center.

F. Video Door Station:

1. Product: IX-DF Vandal Resistant Video Door Station - Flush Mount.
 - a. Power Source: 802.3af PoE.
 - b. Communication: Open voice, hands-free.
 - c. Operating Temperature: -40° - 140°F (-40° - 60°C)
 - d. Camera: Fixed, 1/4-inch color CMOS VGA
 - e. Minimum Illumination: 5 Lux.
 - f. Camera vertical adjustment: +15°, 0°, or -8°.

- g. Door Release: Normally Open dry contact for door release (24V AC/DC, 500mA)
 - h. Dimensions: 10-7/16"H x 5-7/8"W x 2"D
 - 2. Symbol Type VES: Audio / Video Door Station:
 - a. One (1) RJ-45, Cat. 6E, 8-position connector for data cabled to data patch panel in nearest wire center.
 - G. Audio Only Door Station:
 - 1. Product: IX-SS-2G Vandal Resistant Video Door Station - Flush Mount.
 - a. Power Source: 802.3af PoE.
 - b. Communication: Open voice, hands-free.
 - c. Operating Temperature: --40° - 140°F (-40° - 60°C)
 - d. Door Release: Normally Open dry contact for door release (24V AC/DC, 500mA)
 - e. Dimensions: 10-7/16"H x 5-7/8"W x 2"D
 - 2. Symbol Type AES: Audio / Video Door Station:
 - a. One (1) RJ-45, Cat. 6E, 8-position connector for data cabled to data patch panel in nearest wire center.
 - H. Integration and Interfaces
 - 1. Install and setup IX Mobile App on up to eight Owner mobile devices.
 - 2. Interface video door stations to integrated electronic security system and CCTV system for monitoring and recording all activity. Provide CCTV camera licenses.
 - 3. Provide interface to fire alarm system.
- 2.13 SIREN OPERATED SENSOR
- A. Provide a Siren Operated Sensor for the Entry Barrier Gate. Refer to Section 323000 – Site Improvements and drawing T1-0-1 Technology and Security Site Plan. (PROVIDE – 1)
 - 1. Install the Siren Operated Sensor on the Entry Barrier Gate chassis, or as directed by the local First Responder agencies, Police and Fire departments.
 - a. Coordinate with the First Responder agencies for location and programming requirements of the Siren Operated Sensor prior to beginning of all work.
 - 2. Provide all required 18 – 22 AWG wiring for power and wiring to interface the Siren Operated Sensor to the Entry Barrier Gate controller.
 - 3. Test for proper programming and operation as required by the First Responder agencies.
 - 4. Demonstrate the final setup to the First responder agencies and obtain written final approval.
 - B. Manufacturer
 - 1. Basis of Design: model SOS VII by Siren-Operated Sensors, or approved equal

702 Fairfield Street West, Twin Falls, Idaho, 83301
(800) 767-4283
sos@sosgate.com

C. Specifications

Frequency Response: 900Hz to 6Khz

Response (Dry Relay Closure): within 2.5 seconds

Microphone: unidirectional

Range: 5 feet to 50 feet

PC Board: mounted in a 5.5" x 4.7" x 2.4" weather-tight

2.14 SECURITY AND BUILDING SYSTEMS NETWORK EQUIPMENT

A. General

1. Provide all equipment and accessories required in the MDF and IDF closets to establish a fully functioning separate physical Local Area Network for all security and building systems, electrical and HVAC, IP devices.
2. Coordinate with the Owner to determine VLAN setup prior to all work.
3. Equipment and accessories shall consist of, but not be limited to:
 - a. PoE+ Data Switches
 - b. UPS systems
 - c. Fiber Optic OM4 50-micron Multi-mode Duplex Patch Cables
 - d. Category 6e Patch Cables and Line Cords
4. Fiber Optic and Category 6e Data horizontal premises cabling, and 2-post open equipment racks shall be provided by the Division 27 10 00 Subcontractor.

B. PoE+ Data Switches

1. Manufacturer: Subject to compliance with requirements, provide products by one of the following, or approved equal.
 - a. Meraki
 - b. Cisco
 - c. Juniper
2. Provide required quantities of 24-port and/or 48-port Gigabit Stackable PoE+ Switches with management software in the MDF and each IDF closet for security and building system Category 6e cables, including Video Surveillance, Access Control, Gunshot Detection, Vape Detection, HVAC, and Lighting Control system cables.
 - a. Each PoE switch shall not be populated by more than 80% of its available RJ-45 ports.
3. Furnish and install required Modules and SFP Transceivers for a 10GbE connection between the 10GbE aggregate switch in the MDF and the edge switches in IDF closets utilizing OM4 multi-mode fiber strands provided by the Division 27 10 00 Subcontractor.
4. Furnish and install required Modules and SFP Transceivers for 10GbE connection of the CCTV 10GbE aggregate switch in the MDF to the school's data network core switch to be provided by the Owner under a separate contract.
5. Furnish and install required 1GbE Modules and SFP transceivers or rack mounted 10/100/1000 Fiber to UTP media converters to connect each site pole camera to the CCTV network aggregate switch in the MDF.
6. Provide required quantities of Cat 6e and fiber patch cables.

C. Category 6E Patch Cables and Line Cords (Provide quantity as indicated on the drawings)

1. Patch Cable Lengths - Field measure for required lengths

- a. 3 ft
- b. 5 ft
- c. 7 ft

2. Line Cord Lengths

- a. Field measure for required lengths.
- b. Provide minimum required lengths.

2.15 ELECTRIFIED DOOR HARDWARE

A. Section 08 71 00 – Door Hardware

B. Door Hardware Power Supply shall be furnished by the Door Hardware Vendor and installed by the Electrical Subcontractor.

C. Electronic door hardware and power supply for door hardware shall be provided by the Door Hardware Vendor and interfaced to the Access Control and Exterior Door Audio / Video Intercom systems by this Subcontractor.

- 1. Provide control of electronic door hardware (unlock).
- 2. Provide low voltage power cabling from accessible door junction box to electronic door hardware.
- 3. Provide interface and programming for ADA door actuators.

2.16 SYSTEM INTERFACE / INTEGRATION REQUIREMENTS

A. Access Control, Intrusion Alarm, and CCTV Video Surveillance systems shall be installed as an Integrated Electronic Security System.

- 1. Provide all required modules for each system so that all systems are interfaced and integrated.
- 2. Coordinate with the Owner to determine their specific setup and integration requirements for all systems.
- 3. Provide programming to integrate all systems.
- 4. Demonstrate completed Integrated Electronic Security System to the Owner and obtain sign-off from the Owner certifying their satisfaction with the system setup and functionality, and submit sign-off documentation with Closeout materials.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with the installer present, for compliance with requirements for installation tolerances and other conditions affecting the performance of intrusion detection.
 - 1. Examine roughing-in for embedded and built-in anchors to verify actual locations of intrusion detection connections before intrusion detection installation.
 - 2. For the record, prepare a written report endorsed by the installer, listing conditions detrimental to the performance of intrusion detection.
- B. Inspect built-in and cast-in anchor installations before installing intrusion detection to verify that anchor installations comply with requirements. Prepare inspection reports.
 - 1. Remove and replace anchors where inspections indicate that they do not comply with requirements. Re-inspect after repairs or replacements are made.
 - 2. Perform additional inspections to determine compliance of replaced or additional anchor installations. Prepare inspection reports.
- C. For material whose orientation is critical for its performance as a ballistic barrier, verify installation orientation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Wiring Method: Install wiring in metal raceways according to Division 26 Section "Raceway and Boxes for Electrical Systems." Conceal raceway except in unfinished spaces and as indicated. Minimum conduit size shall be 1/2 inch. Control and data transmission wiring shall not share conduit with other building wiring systems.
- B. Wiring Method: Cable, concealed in accessible ceilings, walls, and floors when possible.
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools, separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to the sides and back of the enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the intrusion system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- D. Wires and Cables:
 - 1. Conductors: Size as recommended in writing by the system manufacturer unless otherwise indicated.
 - 2. 120-V Power Wiring: Install according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables," unless otherwise indicated.
 - 3. Control and Signal Transmission Conductors: Install unshielded, twisted-pair cable unless otherwise indicated or if the manufacturer recommends shielded cable, according to Division 28 Section "Conductors and Cables for Electronic Safety and Security."
 - 4. Computer and Data-Processing Cables: Install according to Division 28 Section "Conductors and Cables for Electronic Safety And Security."

5. Television Signal Transmission Cables: Install according to Division 28 Section "Conductors and Cables for Electronic Safety And Security."

- E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
- F. Install power supplies and other auxiliary components for detection devices at controllers, unless otherwise indicated or required by the manufacturer. Do not install such items near the devices they serve.

3.03 GROUNDING

- A. Ground system components and conductor and cable shields to eliminate shock hazards and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- B. Signal Ground Terminal: Locate at the main equipment rack or cabinet. Isolate from the power system and equipment grounding. Provide 5-ohm ground. Measure, record, and report ground resistance.
- C. Install grounding electrodes of type, size, location, and quantity indicated. Comply with installation requirements in Division 26 Section "Grounding and Bonding for Electrical Systems."

3.04 FIRESTOPPING

- A. Apply fire-stopping to penetrations of fire-rated floor and wall assemblies for electronic safety and security installations to restore the original fire-resistance rating of the assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

Repair any disturbed fireproof spray material resulting from this work of this Section.

3.05 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare reports:
 - 1. Inspection: Verify that units and controls are properly labeled, and interconnecting wires and terminals are identified.
 - 2. Operational Tests: Test all modes of system operation and intrusion detection at each detection device. Test for detection of intrusion and for false alarms in each protected zone. Test for false alarms by simulating activities outside indicated detection patterns.
 - 3. Electrical Tests: Comply with NFPA 72, Section A-7. The minimum required tests are as follows:
 - a. Verify the absence of unwanted voltages between circuit conductors and ground.
 - b. Test all conductors for short circuits using an insulation-testing device.
 - c. With each circuit pair, short circuit at the far end of the circuit and measure circuit resistance with an ohmmeter. Record the circuit resistance of each circuit on Record Drawings.
 - d. Verify that each controller is in normal condition as detailed in the manufacturer's operation and maintenance manual.

- e. Test signal and data transmission circuits complying with requirements in Division 28 Section "Conductors and Cables for Electronic Safety and Security" for proper signal transmission under open-circuit conditions. One connection each should be opened at not less than 10 percent of initiating and indicating devices. Observe proper signal transmission according to the class of wiring used.
 - f. Verify that transient surge-protection devices are installed according to the manufacturer's written instructions.
 - g. Test each initiating and indicating device for alarm operation and proper response at the central-station control unit.
 - h. Test both primary and secondary power. Verify, by test, that UPS is capable of operating the system for the period and in the manner specified.
 - C. Report of Tests and Inspections: Prepare a written record of tests, inspections, and detailed test results in the form of a test log.
 - D. Tag all equipment, stations, and other components for which tests have been satisfactorily completed.
- 3.06 ADJUSTING
- A. Occupancy Adjustments: When requested within 24 months installer's warranty provide on-site assistance in adjusting the system to suit actual occupied conditions at no additional cost.
 - B. Provide up to eight site visits to the project during other than normal occupancy hours for this purpose.
 - C. Visits for this purpose shall be in addition to any required warranty maintenance or.
- 3.07 CLEANUP
- A. Upon completion of all work and testing, thoroughly inspect all exposed portions of the installation and completely remove all exposed labels, markings, and foreign material.
 - 1. The interior of all boxes and cabinets shall be left clean; exposed surfaces shall be cleaned, and plated surfaces polished.
 - 2. Remove material and equipment from areas of work and storage areas.
 - 3. All equipment shall be clean from dirt, dust, and fingerprints prior to final acceptance.
 - 4. Touch up all damaged pre-finished equipment using materials and methods recommended by the Manufacturer.
- 3.08 PROJECT CLOSEOUT
- A. Provide close-out submittals as required herein and in Section 01 77 00 – Closeout Procedures, including the following close out submittals.
 - 1. Operation and Maintenance Manuals.
 - 2. Record Drawings with "as-built" corrections
 - 3. "As-built" telecommunications Drawings.
 - 4. All Test Reports
 - 5. All Warranties
 - 6. Copies of video recordings of training sessions
 - 7. Loose Equipment
 - 8. Extra Materials

- B. Provide copies of written delivery receipts of materials and/or equipment. Receipts shall specifically detail what was delivered (description, quantity, and specification section) and shall be dated and signed by delivery firm and by an owner's representative.
- C. Provide copies of all signed training and acceptance documentation.

END OF SECTION

SECTION 284621

ADDRESSABLE FIRE ALARM SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Addressable fire-alarm system.
2. Fire-alarm control unit (FACU).
3. Manual fire-alarm boxes.
4. System smoke detectors.
5. Duct smoke detectors.
6. Projected beam smoke detectors.
7. Carbon monoxide detectors.
8. Fire-alarm notification appliances.
9. Firefighters' two-way telephone communication service.
10. Emergency responder radio coverage system.
11. Fire-alarm remote annunciators.
12. Fire-alarm addressable interface devices.
13. Fire-alarm radio transmitters.

- B. Related Requirements:

1. Section 087100 "Door Hardware" for magnetic door holders that release in response to fire-alarm outputs.
2. Section 260519 "Low-Voltage Electrical Power Conductors and Cables" or Section 260523 "Control Voltage Electrical Power Cables" for cables and conductors for fire-alarm systems.
3. Section 284700 "Mass Notification" for mass notification features that are required in addition to fire-alarm system and equipment requirements specified in this Section.

1.3 DEFINITIONS

- A. DACT: Digital alarm communicator transmitter.
- B. EMT: Electrical metallic tubing.
- C. FACU: Fire-alarm control unit.
- D. High-Performance Building: A building that integrates and optimizes on a life-cycle basis all major high-performance attributes, including energy conservation, environment, safety, security,

- E. durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations.
- F. Mode: The terms "Active Mode," "Off Mode," and "Standby Mode" are used as defined in the 2007 Energy Independence and Security Act (EISA).
- G. NICET: National Institute for Certification in Engineering Technologies.
- H. PC: Personal computer.
- I. Voltage Class: For specified circuits and equipment, voltage classes are defined as follows:
 - 1. Control Voltage: Listed and labeled for use in remote-control, signaling, and power-limited circuits supplied by a Class 2 or Class 3 power supply having rated output not greater than 150 V and 5 A, allowing use of alternate wiring methods complying with NFPA 70, Article 725.
 - 2. Low Voltage: Listed and labeled for use in circuits supplied by a Class 1 or other power supply having rated output not greater than 1000 V, requiring use of wiring methods complying with NFPA 70, Article 300, Part I.

1.4 ACTION SUBMITTALS

- A. Approved Permit Submittal: Submittals must be approved by authorities having jurisdiction prior to submitting them to Architect.
- B. Product Data: For each type of product, including furnished options and accessories.
 - 1. Include construction details, material descriptions, dimensions, profiles, and finishes.
 - 2. Include rated capacities, operating characteristics, and electrical characteristics.
- C. Shop Drawings: For fire-alarm system.
 - 1. Comply with recommendations and requirements in "Documentation" section of "Fundamentals" chapter in NFPA 72.
 - 2. Include plans, elevations, sections, and details, including details of attachments to other Work.
 - 3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
 - 4. Annunciator panel details as required by authorities having jurisdiction.
 - 5. Detail assembly and support requirements.
 - 6. Include voltage drop calculations for notification-appliance circuits.
 - 7. Include battery-size calculations.
 - 8. Include input/output matrix.
 - 9. Include written statement from manufacturer that equipment and components have been tested as a system and comply with requirements in this Section and in NFPA 72.
 - 10. Include performance parameters and installation details for each detector.
 - 11. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
 - 12. Provide control wiring diagrams for fire-alarm interface to HVAC; coordinate location of duct smoke detectors and access to them.
 - a. Show field wiring and equipment required for HVAC unit shutdown on alarm.
 - b. Locate detectors in accordance with manufacturer's written instructions.

13. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
 14. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.
- D. Delegated Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by qualified professional engineer responsible for their preparation.
1. Drawings showing location of each notification appliance and smoke detector, ratings of each, and installation details as needed to comply with listing conditions of device.
 2. Design Calculations: Calculate requirements for selecting spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
 3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.5 INFORMATIONAL SUBMITTALS

- A. Certificates:
1. Seismic Performance Certificates: For FACU, accessories, and components, from manufacturer. Include the following information:
 - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - c. Detailed description of equipment anchorage devices on which certification is based and their installation requirements.
- B. Field quality-control reports.
- C. Qualification Statements: For Installer.
- D. Sample Warranty: Submittal must include line item pricing for replacement parts and labor.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Comply with "Records" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - b. Provide "Fire-Alarm and Emergency Communications System Record of Completion Documents" in accordance with "Completion Documents" Article in "Documentation" section of "Fundamentals" chapter in NFPA 72.
 - c. Complete wiring diagrams showing connections between devices and equipment. Each conductor must be numbered at every junction point with indication of origination and termination points.
 - d. Riser diagram.

- e. Device addresses.
- f. Record copy of site-specific software.
- g. Provide "Inspection and Testing Form" in accordance with "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
 - 1) Equipment tested.
 - 2) Frequency of testing of installed components.
 - 3) Frequency of inspection of installed components.
 - 4) Requirements and recommendations related to results of maintenance.
 - 5) Manufacturer's user training manuals.
- h. Manufacturer's required maintenance related to system warranty requirements.
- i. Abbreviated operating instructions for mounting at FACU and each annunciator unit.

B. Software and Firmware Operational Documentation:

- 1. Software operating and upgrade manuals.
- 2. Program Software Backup: On USB media and approved online or cloud solution.
- 3. Device address list.
- 4. Printout of software application and graphic screens.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Extra Stock Material: Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

- 1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
- 2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
- 3. Smoke Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
- 4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
- 5. Keys and Tools: One extra set for access to locked or tamperproofed components.
- 6. Audible and Visual Notification Appliances: One of each type installed.
- 7. Fuses: Two of each type installed in system. Provide in box or cabinet with compartments marked with fuse types and sizes.
- 8. Filters for Air-Sampling Detectors: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.

1.8 QUALITY ASSURANCE

A. Installer Qualifications:

- 1. Personnel must be trained and certified by manufacturer for installation of units required for this Project.
- 2. Installation must be by personnel certified by NICET as fire-alarm Level III technician.
- 3. Obtain certification by NRTL in accordance with NFPA 72.
- 4. Licensed or certified by authorities having jurisdiction.

1.9 FIELD CONDITIONS

- A. Seismic Conditions: Unless otherwise indicated on Contract Documents, specified Work in this Section must withstand the seismic hazard design loads determined in accordance with ASCE/SEI 7 installed elevation above or below grade.
1. The term "withstand" means "unit must remain in place without separation of parts from unit when subjected to specified seismic design loads and unit must be fully operational after seismic event."

1.10 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail because of defects in materials or workmanship within specified warranty period.
1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 ADDRESSABLE FIRE-ALARM SYSTEM

- A. Description:
1. Noncoded, UL-certified, FM Global-placarded addressable system, with multiplexed signal transmission and voice-and-strobe notification for evacuation.
- B. Performance Criteria:
1. Regulatory Requirements:
 - a. Fire-Alarm Components, Devices, and Accessories: Listed and labeled by a NRTL in accordance with NFPA 70 for use with selected fire-alarm system and marked for intended location and application.
 2. General Characteristics:
 - a. Automatic sensitivity control of certain smoke detectors.
 - b. Fire-alarm signal initiation must be by one or more of the following devices and systems:
 - 1) Manual stations.
 - 2) Smoke detectors.
 - 3) Duct smoke detectors.
 - 4) Carbon monoxide detectors.
 - 5) Automatic sprinkler system water flow.
 - 6) Fire-extinguishing system operation.
 - 7) Fire standpipe system.
 - c. Fire-alarm signal must initiate the following actions:
 - 1) Continuously operate alarm notification appliances, including voice evacuation notices.
 - 2) Identify alarm and specific initiating device at FACU, connected network

ADDRESSABLE FIRE-ALARM SYSTEMS

- control panels, and remote annunciators.
 - 3) Transmit alarm signal to remote alarm receiving station.
 - 4) Unlock electric door locks in designated egress paths.
 - 5) Release fire and smoke doors held open by magnetic door holders.
 - 6) Activate voice/alarm communication system.
 - 7) Switch HVAC equipment controls to fire-alarm mode.
 - 8) Activate stairwell and elevator-shaft pressurization systems.
 - 9) Close smoke dampers in air ducts of designated air-conditioning duct systems.
 - 10) Recall elevators to primary or alternate recall floors.
 - 11) Activate elevator power shunt trip.
 - 12) Activate emergency lighting control.
 - 13) Activate emergency shutoffs for gas and fuel supplies.
 - 14) Record events in system memory.
 - 15) Record events by system printer.
 - 16) Indicate device in alarm on graphic annunciator.
- d. Supervisory signal initiation must be by one or more of the following devices and actions:
- 1) Valve supervisory switch.
 - 2) Alert and Action signals of air-sampling detector system.
 - 3) Elevator shunt-trip supervision.
 - 4) Independent fire-detection and -suppression systems.
 - 5) Fire pump is running.
 - 6) Fire pump has lost power.
 - 7) Power to fire pump has phase reversal.
 - 8) Zones or individual devices have been disabled.
 - 9) FACU has lost communication with network.
- e. System trouble signal initiation must be by one or more of the following devices and actions:
- 1) Open circuits, shorts, and grounds in designated circuits.
 - 2) Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
 - 3) Loss of communication with addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
 - 4) Loss of primary power at FACU.
 - 5) Ground or single break in internal circuits of FACU.
 - 6) Abnormal ac voltage at FACU.
 - 7) Break in standby battery circuitry.
 - 8) Failure of battery charging.
 - 9) Abnormal position of switch at FACU or annunciator.
 - 10) Voice signal amplifier failure.
 - 11) Hose cabinet door open.
- f. System Supervisory Signal Actions:
- 1) Initiate notification appliances.
 - 2) Identify specific device initiating event at FACU and remote annunciators.
 - 3) Record event on system printer.
 - 4) After time delay of 200 seconds, transmit trouble or supervisory signal to

- remote alarm receiving station.
- 5) Transmit system status to building management system.
- 6) Display system status on graphic annunciator.
- g. Network Communications:
 - 1) Provide network communications for fire-alarm system in accordance with fire-alarm manufacturer's written instructions.
 - 2) Provide network communications pathway per manufacturer's written instructions and requirements in NFPA 72 and NFPA 70.
 - 3) Provide integration gateway using BACnet for connection to building automation system.
- h. System Printer:
 - 1) Printer must be listed and labeled as integral part of fire-alarm system.
- i. Device Guards:
 - 1) Description: Welded wire mesh of size and shape for manual station, smoke detector, gong, or other device requiring protection.
 - a) Factory fabricated and furnished by device manufacturer.
 - b) Finish: Paint of color to match protected device.
- j. Document Storage Box:
 - 1) Description: Enclosure to accommodate standard 8-1/2-by-11 inch manuals and loose document records. Legend sheet will be permanently attached to door for system required documentation, key contacts, and system information. Provide two key ring holders with location to mount standard business cards for key contact personnel.
 - 2) Material and Finish: 18-gauge cold-rolled steel; four mounting holes.
 - 3) Color: Red powder-coat epoxy finish.
 - 4) Labeling: Permanently screened with 1 inch high lettering "SYSTEM RECORD DOCUMENTS" with white indelible ink.
 - 5) Security: Locked with 3/4 inch barrel lock. Provide solid 12 inch stainless steel piano hinge.

2.2 FIRE-ALARM CONTROL UNIT (FACU)

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Edwards; Carrier Global Corporation.
 - 2. Notifier; Honeywell International, Inc.
 - 3. Siemens Industry, Inc., Building Technologies Division.
 - 4. Simplex; brand of Johnson Controls International plc, Building Solutions North America.
- B. Description: Field-programmable, microprocessor-based, modular, power-limited design with electronic modules.
- C. Performance Criteria:

1. Regulatory Requirements: Comply with NFPA 72 and UL 864.
2. General Characteristics:
 - a. System software and programs must be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining information through failure of primary and secondary power supplies.
 - b. Include real-time clock for time annotation of events on event recorder and printer.
 - c. Provide communication between FACU and remote circuit interface panels, annunciators, and displays.
 - d. FACU must be listed for connection to central-station signaling system service.
 - e. Provide nonvolatile memory for system database, logic, and operating system and event history. System must require no manual input to initialize in the event of complete power down condition. FACU must provide minimum 500-event history log.
 - f. Addressable Initiation Device Circuits: FACU must indicate which communication zones have been silenced and must provide selective silencing of alarm notification appliance by building communication zone.
 - 1) Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: FACU must be listed for releasing service.
 - g. Fire-Alarm Annunciator: Arranged for interface between human operator at FACU and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and programming and control menu.
 - 1) Annunciator and Display: LCD, 80 characters, minimum.
 - 2) Keypad: Arranged to permit entry and execution of programming, display, and control commands.
 - h. Alphanumeric Display and System Controls: Arranged for interface between human operator at FACU and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and programming and control menu.
 - 1) Annunciator and Display: LCD, three line(s) of 80 characters, minimum.
 - 2) Keypad: Arranged to permit entry and execution of programming, display, and control commands.
 - i. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:
 - 1) Pathway Class Designations: NFPA 72, Class A
 - 2) Pathway Survivability: Level 1.
 - 3) Install no more than 256 addressable devices on each signaling-line circuit.
 - 4) Install fault circuit isolators to comply with circuit performance requirements of NFPA 72 or with manufacturer's written instructions, whichever is more conservative.
 - j. Serial Interfaces:
 - 1) One dedicated RS 485 port for remote station operation using point ID DACT.
 - 2) One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).

- 3) One USB port for PC configuration.
 - 4) One RS 232 port for voice evacuation interface.
- k. Stairwell and Elevator Shaft Pressurization: Provide output signal using addressable relay to start stairwell and elevator shaft pressurization system. Signal must remain on until alarm conditions are cleared, and fire-alarm system is reset. Signal must not stop in response to alarm acknowledge or signal silence commands.
- 1) Pressurization starts when alarm is received at FACU.
 - 2) Alarm signals from smoke detectors at pressurization air supplies have higher priority than other alarm signals that start system.
- l. Notification-Appliance Circuit:
- 1) Audible appliances must sound in three-pulse temporal pattern, as defined in NFPA 72.
 - 2) Where notification appliances provide signals to sleeping areas, alarm signal must be 520 Hz square wave with intensity 15 dB above average ambient sound level or 5 dB above maximum sound level, or at least 75 dB(A-weighted), whichever is greater, measured at pillow.
 - 3) Visual alarm appliances must flash in synchronization where multiple appliances are in same field of view, as defined in NFPA 72.
- m. Elevator Recall: Initiate by one of the following alarm-initiating devices:
- 1) Elevator lobby detectors except lobby detector on designated floor.
 - 2) Smoke detectors in elevator machine room.
 - 3) Smoke detectors in elevator hoistway.
- n. Elevator controller must be programmed to move cars to alternate recall floor if lobby detectors located on designated recall floors are activated.
- o. Water-flow alarm connected to sprinkler in elevator shaft and elevator machine room must shut down elevators associated with location without time delay.
- 1) Water-flow switch associated with sprinkler in elevator pit may have delay to allow elevators to move to designated floor.
- p. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls must be connected to fire-alarm system.
- q. Remote Smoke-Detector Sensitivity Adjustment: Controls must select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory and print out final adjusted values on system printer.
- r. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to remote alarm station.
- s. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided as special module that is part of FACU.
- t. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of central-control microphone. Amplifiers must comply with UL 1711.

- 1) Allow application of, and evacuation signal to, indicated number of zones and simultaneously allow voice paging to other zones selectively or in combination.
 - 2) Programmable tone and message sequence selection.
 - 3) Standard digitally recorded messages for "Evacuation" and "All Clear."
 - 4) Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification- appliance circuits of FACU.
-
- u. Status Annunciator: Indicate status of various voice/alarm speaker zones and status of firefighters' two-way telephone communication zones.
 - v. Preamplifiers, amplifiers, and tone generators must automatically transfer to backup units, on primary equipment failure.
 - w. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from other printed indications. Also, print system reset event, including same information for device, location, date, and time. Commands initiate printing of list of existing alarm, supervisory, and trouble conditions in system and historical log of events.
 - x. Primary Power: 24 V(dc) obtained from 120 V(ac) service and power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals and digital alarm radio transmitters must be powered by 24 V(dc) source.
 - y. Alarm current draw of entire fire-alarm system must not exceed 80 percent of power-supply module rating.
 - z. Secondary Power: 24 V(dc) supply system with batteries, automatic battery charger, and automatic transfer switch.
 - aa. Batteries: Sealed, valve-regulated, recombinant lead acid.

D. Accessories:

1. Instructions: Computer printout or typewritten instruction card mounted behind plastic or glass cover in stainless steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe functional operation of system under normal, alarm, and trouble conditions.

2.3 MANUAL FIRE-ALARM BOXES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Autocall; brand of Johnson Controls International plc, Building Solutions North America.
2. Bosch Security Systems, Inc.
3. Edwards; Carrier Global Corporation.
4. Federal Signal Corporation.
5. Fike Corporation.
6. Fire-Lite Alarms; Honeywell International, Inc.
7. Gamewell-FCI; Honeywell International, Inc.
8. Mircom Technologies, Ltd.
9. Notifier; Honeywell International, Inc.
10. Potter Electric Signal Company, LLC.
11. Siemens Industry, Inc., Building Technologies Division.
12. Silent Knight; Honeywell International, Inc.

13. Simplex; brand of Johnson Controls International plc, Building Solutions North America.
14. Valcom, Inc. (Keltron Corporation).
15. Wheelock, Life Safety and Mass Notification; Eaton, Electrical Sector.

- B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes must be finished in red with molded, raised-letter operating instructions in contrasting color; must show visible indication of operation; and must be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Single-action mechanism, breaking-glass, or plastic-rod type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to FACU.
2. Double-action mechanism requiring two actions to initiate alarm, breaking-glass, or plastic-rod type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to FACU.
3. Station Reset: Key- or wrench-operated switch.
4. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at top to permit lifting for access to initiate alarm. Lifting cover actuates integral battery-powered audible horn intended to discourage false-alarm operation.
5. Weatherproof Protective Shield: Factory-fabricated, clear plastic enclosure hinged at top to permit lifting for access to initiate alarm.
6. Able to perform at up to 90 percent relative humidity at 90 deg F.
7. Material: Manual stations made of Lexan polycarbonate.
8. Able to be used in indoor or outdoor areas.

2.4 SYSTEM SMOKE DETECTORS

- A. Photoelectric Smoke Detectors:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Autocall; brand of Johnson Controls International plc, Building Solutions North America.
 - b. Bosch Security Systems, Inc.
 - c. Edwards; Carrier Global Corporation.
 - d. Fire-Lite Alarms; Honeywell International, Inc.
 - e. Gamewell-FCI; Honeywell International, Inc.
 - f. Gentex Corporation.
 - g. Harrington Signal, Inc.
 - h. Mircom Technologies, Ltd.
 - i. Notifier; Honeywell International, Inc.
 - j. Potter Electric Signal Company, LLC.
 - k. Siemens Industry, Inc., Building Technologies Division.
 - l. Silent Knight; Honeywell International, Inc.
 - m. Simplex; brand of Johnson Controls International plc, Building Solutions North America.
2. Performance Criteria:
 - a. Regulatory Requirements:
 - 1) NFPA 72.
 - 2) UL 268.

b. General Characteristics:

- 1) Detectors must be two-wire type.
- 2) Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
- 3) Base Mounting: Detector and associated electronic components must be mounted in twist-lock module that connects to fixed base. Provide terminals in fixed base for connection to building wiring.
- 4) Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
- 5) Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
- 6) Detector address must be accessible from FACU and must be able to identify detector's location within system and its sensitivity setting.
- 7) Operator at FACU, having designated access level, must be able to manually access the following for each detector:
 - a) Primary status.
 - b) Device type.
 - c) Present average value.
 - d) Present sensitivity selected.
 - e) Sensor range (normal, dirty, etc.).
- 8) Detector must have functional humidity range within 10 to 90 percent relative humidity.
- 9) Color: White.
- 10) Remote Control: Unless otherwise indicated, detectors must be digital-addressable type, individually monitored at FACU for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by FACU.
- 11) Multiple levels of detection sensitivity for each sensor.
- 12) Sensitivity levels based on time of day.

2.5 DUCT SMOKE DETECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Autocall; brand of Johnson Controls International plc, Building Solutions North America.
2. Bosch Security Systems, Inc.
3. Edwards; Carrier Global Corporation.
4. Fire-Lite Alarms; Honeywell International, Inc.
5. Gamewell-FCI; Honeywell International, Inc.
6. Gentex Corporation.
7. Harrington Signal, Inc.
8. Mircom Technologies, Ltd.
9. Notifier; Honeywell International, Inc.
10. Potter Electric Signal Company, LLC.
11. Siemens Industry, Inc., Building Technologies Division.
12. Silent Knight; Honeywell International, Inc.
13. Simplex; brand of Johnson Controls International plc, Building Solutions North America.

B. Description: Photoelectric-type, duct-mounted smoke detector.

C. Performance Criteria:

1. Regulatory Requirements:

- a. NFPA 72.
- b. UL 268A.

2. General Characteristics:

- a. Detectors must be two-wire type.
- b. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
- c. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
- d. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
- e. Detector address must be accessible from FACU and must be able to identify detector's location within system and its sensitivity setting.
- f. Operator at FACU, having designated access level, must be able to manually access the following for each detector:
 - 1) Primary status.
 - 2) Device type.
 - 3) Present average value.
 - 4) Present sensitivity selected.
 - 5) Sensor range (normal, dirty, etc.).
- g. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with supplied detector for smoke detection in HVAC system ducts.
- h. Each sensor must have multiple levels of detection sensitivity.
- i. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
- j. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

2.6 CARBON MONOXIDE DETECTORS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Notifier; Honeywell International, Inc.

B. Description: Carbon monoxide detector listed for connection to fire-alarm system.

C. Performance Criteria:

1. Regulatory Requirements:

- a. NFPA 72
- b. NFPA 720.
- c. UL 2075.

2. General Characteristics:

- a. Mounting: Adapter plate for outlet box mounting.
- b. Testable by introducing test carbon monoxide into sensing cell.

- c. Detector must provide alarm contacts and trouble contacts.
- d. Detector must send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
- e. Locate, mount, and wire in accordance with manufacturer's written instructions.
- f. Provide means for addressable connection to fire-alarm system.
- g. Test button simulates alarm condition.

2.7 FIRE-ALARM NOTIFICATION APPLIANCES

A. Fire-Alarm Voice/Tone Notification Appliances:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Autocall; brand of Johnson Controls International plc, Building Solutions North America.
 - b. Edwards; Carrier Global Corporation.
 - c. Federal Signal Corporation.
 - d. Gentex Corporation.
 - e. Harrington Signal, Inc.
 - f. Mircom Technologies, Ltd.
 - g. Notifier; Honeywell International, Inc.
 - h. Potter Electric Signal Company, LLC.
 - i. Siemens Industry, Inc., Building Technologies Division.
 - j. Simplex; brand of Johnson Controls International plc, Building Solutions North America.
 - k. Valcom, Inc. (Keltron Corporation).
 - l. Wheelock, Life Safety and Mass Notification; Eaton, Electrical Sector.
2. Description: Notification appliances capable of outputting voice evacuation messages.
3. Performance Criteria:
 - a. Regulatory Requirements:
 - 1) NFPA 72.
 - 2) UL 1480.
 - b. General Characteristics:
 - 1) Speakers for Voice Notification: Locate speakers for voice notification to provide intelligibility requirements of "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.
 - 2) High-Range Units: Rated 2 to 15 W.
 - 3) Low-Range Units: Rated 1 to 2 W.
 - 4) Mounting: surface mounted and bidirectional.
 - 5) Matching Transformers: Tap range matched to acoustical environment of speaker location.
 - 6) Combination Devices: Factory-integrated audible and visible devices in single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.

B. Fire-Alarm Visible Notification Appliances:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Autocall; brand of Johnson Controls International plc, Building Solutions North America.
 - b. Edwards; Carrier Global Corporation.
 - c. Federal Signal Corporation.
 - d. Gentex Corporation.
 - e. Harrington Signal, Inc.
 - f. Mircom Technologies, Ltd.
 - g. Notifier; Honeywell International, Inc.
 - h. Potter Electric Signal Company, LLC.
 - i. Siemens Industry, Inc., Building Technologies Division.
 - j. Simplex; brand of Johnson Controls International plc, Building Solutions North America.
 - k. Valcom, Inc. (Keltron Corporation).
 - l. Wheelock, Life Safety and Mass Notification; Eaton, Electrical Sector.
2. Performance Criteria:
 - a. Regulatory Requirements:
 - 1) NFPA 72.
 - 2) UL 1971.
 - b. General Characteristics:
 - 1) Rated Light Output:
 - a) 15/30/75/110 cd, selectable in field.
 - 2) Clear or nominal white polycarbonate lens mounted on aluminum faceplate.
 - 3) Mounting: Wall mounted unless otherwise indicated.
 - 4) For units with guards to prevent physical damage, light output ratings must be determined with guards in place.
 - 5) Flashing must be in temporal pattern, synchronized with other units.
 - 6) Strobe Leads: Factory connected to screw terminals.
 - 7) Mounting Faceplate: Factory finished, [red] [white].

2.8 FIREFIGHTERS' TWO-WAY TELEPHONE COMMUNICATION SERVICE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Gamewell-FCI; Honeywell International, Inc.
 2. Notifier; Honeywell International, Inc.
- B. Description: Dedicated, two-way, supervised, telephone voice communication links between FACU, and remote firefighters' telephone stations. Supervised telephone lines must be connected to talk circuits by controls in control module.
- C. Performance Criteria:

1. Regulatory Requirements:
 - a. NFPA 72.
2. General Characteristics:
 - a. Common-talk type for firefighter use only.
 - b. Selective-talk type for use by firefighters and fire wardens.
 - c. Controls to disconnect phones from talk circuits if too many phones are in use simultaneously. Indicator lamp must flash if phone is disconnected from talk circuits.
 - d. Addressable firefighters' phone modules to monitor and control loop of firefighter phones. Module must be capable of differentiating between normal, off-hook, and trouble conditions.
 - e. Audible Pulse and Tone Generator, and High-Intensity Lamp: When remote telephone is taken off hook, it causes audible signal to sound and high-intensity lamp to flash at FACU.
 - f. Selector panel controls to provide for simultaneous operation of up to six telephones in selected zones. Indicate ground faults and open or shorted telephone lines on panel front by individual LEDs.
 - g. Display: Graphic to indicate location of caller.
 - h. Remote Telephone Cabinet: Flush- or surface-mounted cabinet as indicated; factory- standard red finish; with handset.
 - 1) Install one-piece handset to cabinet with vandal-resistant armored cord. Silk-screened or engraved label on cabinet door, designating "Fire Emergency Phone."
 - 2) With "break-glass" door access lock.
 - i. Remote Telephone Jack Stations: Single-gang, stainless steel-plate mounted plug, engraved "Fire Emergency Phone."
 - j. Handsets: 12 [push-to-talk] sets with noise-canceling microphone stored in cabinet adjacent to FACU.

2.9 EMERGENCY RESPONDER RADIO COVERAGE SYSTEM

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Autocall; brand of Johnson Controls International plc, Building Solutions North America.
 2. Radio Solutions Inc.
 3. TESSCO Technologies Incorporated.
 4. Fiplex Communications, Honeywell International, Inc.
- B. Description: Emergency responder radio coverage systems use a combination of bidirectional amplifiers and distributed antenna systems to boost signals for sustaining two-way radio communications throughout a facility, including stairwells, underground tunnels, parking garages, and other challenging areas.

C. Performance Criteria:

1. Regulatory Requirements:

- a. In accordance with NFPA 72, emergency responder radio coverage systems must be designed, installed, and maintained in accordance with NFPA 1221.

2. General Characteristics:

- a. Where emergency responder radio coverage system is used in lieu of two-way in-building wired emergency communications system, it must have pathway survivability of Level 1, 2, or 3 as defined in NFPA 72.
- b. Where leaky feeder cable is used as antenna, it must neither be required to be installed in metal raceway nor meet survivability requirements.
- c. Feeder and riser coaxial cables must be rated as plenum cables.
- d. Feeder coaxial cables must be connected to riser coaxial cables using hybrid coupler devices of value determined by overall design.
- e. Where emergency responder radio coverage system is used in lieu of two-way in-building wired emergency communications system, design of system must be approved by authorities having jurisdiction. Riser coaxial cables must be rated as riser cables and routed through 2-hour-rated enclosure.
- f. Connection between riser and feeder coaxial cables must be made within 2-hour-rated enclosure, and passage of feeder cable in and out of 2-hour-rated enclosure must be firestopped to 2-hour ratings.

2.10 FIRE-ALARM REMOTE ANNUNCIATORS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

- 1. Bosch Security Systems, Inc.

B. Performance Criteria:

1. Regulatory Requirements:

- a. NFPA 72.

2. General Characteristics:

- a. Annunciator functions must match those of FACU for alarm, supervisory, and trouble indications. Manual switching functions must match those of FACU, including acknowledging, silencing, resetting, and testing.
 - 1) Mounting: Surface cabinet, NEMA 250, Type 1.
- b. Display Type and Functional Performance: Alphanumeric display and LED indicating lights must match those of FACU. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.11 FIRE-ALARM ADDRESSABLE INTERFACE DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Bosch Security Systems, Inc.
 - 2. Notifier; Honeywell International, Inc.
- B. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. NFPA 72.
 - 2. General Characteristics:
 - a. Include address-setting means on module.
 - b. Store internal identifying code for control panel use to identify module type.
 - c. Listed for controlling HVAC fan motor controllers.
 - d. Monitor Module: Microelectronic module providing system address for alarm-initiating devices for wired applications with normally open contacts.
 - e. Integral Relay: Capable of providing direct signal ,to elevator controller to initiate elevator recall and to circuit-breaker shunt trip for power shutdown.
 - 1) Allow control panel to switch relay contacts on command.
 - 2) Have minimum of two normally open and two normally closed contacts available for field wiring.
 - f. Control Module:
 - 1) Operate notification devices.
 - 2) Operate solenoids for use in sprinkler service.
 - 3) Shunt all A/V and/or sound equipment.
 - 4) Release all security devices.
 - 5) Bring all dimmed luminaires to full brightness

2.12 FIRE-ALARM RADIO TRANSMITTERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Kingfisher Company, Inc.
- B. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. NFPA 72.
 - b. NFPA 1221.

- c. 47 CFR 90.

2. General Characteristics:

- a. Must be factory assembled, wired, and tested; ready for installation and operation.
- b. Packaging: Single, modular, NEMA 250, Type 1 metal enclosure with tamper-resistant flush tumbler lock.
- c. Signal Transmission Mode and Frequency: VHF or UHF 2-W power output, coordinated with operating characteristics of established remote alarm receiving station designated by Owner.
- d. Normal Power Input: 120 V(ac).
- e. Secondary Power: Integral-sealed, rechargeable, 12 V battery and charger. Comply with NFPA 72 requirements for battery capacity; submit calculations.
 - 1) Antenna: Omnidirectional, coaxial half-wave, dipole type with driving point impedance matched to transmitter and antenna cable output impedance. Wind-load strength of antenna and mounting hardware and supports must withstand 100 mph with gust factor of 1.3 without failure.
 - 2) Antenna Cable: Coaxial cable with impedance matched to transmitter output impedance.
 - 3) Antenna-Cable Connectors: Weatherproof.
 - 4) Alarm Interface Devices: Circuit boards, modules, and other auxiliary devices, integral to transmitter, matching fire-alarm and other system outputs to message-generating inputs of transmitter that produce required message transmissions.
- f. Functional Performance: Unit must receive alarm, supervisory, or trouble signal from FACU or from its own internal sensors or controls and must automatically transmit signal along with unique code that identifies transmitting station to remote alarm receiving station. Transmitted messages must correspond to standard designations for fire-reporting system to which signal is being transmitted and must include separately designated messages in response to the following events or conditions:
 - 1) Transmitter Low-Battery Condition: Sent when battery voltage is below 85 percent of rated value.
 - 2) System Test Message: Initiated manually by test switch within transmitter cabinet, or automatically at optionally preselected time, once every 24 hours, with transmission time controlled by programmed timing device integral to transmitter controls.
 - 3) Transmitter Trouble Message: Actuated by failure, in excess of one-minute duration, of transmitter normal power source, derangement of wiring of transmitter, or alarm input interface circuit or device connected to it.
 - 4) Local Fire-Alarm-System Trouble Message: Initiated by events or conditions that cause trouble signal to be indicated on building system.
 - 5) Local Fire-Alarm-System Alarm Message: Actuated when building system goes into alarm state. Identifies device that initiated alarm.
 - 6) Local Fire-Alarm-System, Supervisory-Alarm Message: Actuated when building alarm system indicates supervisory alarm.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.
 - 1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.
- B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Preinstallation Testing: Perform verification of functionality of installed components of existing system prior to starting work. Document equipment or components not functioning as designed.
- B. Protection of In-Place Conditions: Protect devices during construction unless devices are placed in service to protect facility during construction.

3.3 INSTALLATION OF EQUIPMENT

- A. Comply with NECA 305, NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."
 - 1. Devices placed in service before other trades have completed cleanup must be replaced.
 - 2. Devices installed, but not yet placed, in service must be protected from construction dust, debris, dirt, moisture, and damage in accordance with manufacturer's written storage instructions.
- B. Equipment Floor Mounting: Install FACU on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Install seismic bracing. Comply with requirements in Section 270548.16 "Seismic Controls for Communications Systems."
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18 inch centers around full perimeter of concrete base.
 - 3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

5. Install anchor bolts to elevations required for proper attachment to supported equipment.
- C. Equipment Floor and Wall Mounting: Install FACU on finished floor.
 1. Comply with requirements for seismic-restraint devices specified in Section 270548.16 "Seismic Controls for Communications Systems."
- D. Install wall-mounted equipment, with tops of cabinets not more than 78 inch above finished floor.
- E. Manual Fire-Alarm Boxes:
 1. Install manual fire-alarm box in normal path of egress within 60 inch of exit doorway.
 2. Mount manual fire-alarm box on background of contrasting color.
 3. Operable part of manual fire-alarm box must be between 42 and 48 inch above floor level. Devices must be mounted at same height unless otherwise indicated.
- F. Smoke Spacing:
 1. Comply with "Smoke-Sensing Fire Detectors" section in "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
 2. Comply with "Heat-Sensing Fire Detectors" section in "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
 3. Smooth ceiling spacing must not exceed 30 ft.
 4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas must be determined in accordance with Annex A or Annex B in NFPA 72.
 5. HVAC: Locate detectors not closer than 36 inch from air-supply diffuser or return-air opening.
 6. Lighting Fixtures: Locate detectors not closer than 12 inch from lighting fixture and not directly above pendant mounted or indirect lighting.
- G. Install cover on each smoke detector that is not placed in service during construction. Cover must remain in place except during system testing. Remove cover prior to system turnover.
- H. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend full width of duct. Tubes more than 36 inch long must be supported at both ends.
 1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.
- I. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.
- J. Remote Status and Alarm Indicators: Install in visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.
- K. Audible Alarm-Indicating Devices: Install not less than 6 inch below ceiling. Install bells and horns on flush-mounted back boxes with device-operating mechanism concealed behind grille. Install devices at same height unless otherwise indicated.

- L. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inch below ceiling. Install devices at same height unless otherwise indicated.
- M. Device Location-Indicating Lights: Locate in public space near device they monitor.
- N. Antenna for Radio Alarm Transmitter: Mount to building structure where indicated. Use mounting arrangement and substrate connection that resists wind load of 100 mph with gust factor of 1.3 without damage.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate must be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate must be laminated acrylic or melamine plastic signs with black background and engraved white letters at least 1/2 inch high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

3.6 PATHWAYS

- A. Pathways above recessed ceilings and in inaccessible locations may be routed exposed.
 - 1. Exposed pathways located less than 96 inch above floor must be installed in EMT.
- B. Pathways must be installed in EMT.
- C. Exposed EMT must be painted red enamel.

3.7 CONNECTIONS

- A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.
 - 1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.
- B. Make addressable connections with supervised interface device to the following devices and systems. Install interface device less than 36 inch from device controlled. Make addressable confirmation connection when such feedback is available at device or system being controlled.
 - 1. Alarm-initiating connection to smoke-control system (smoke management) at firefighters' smoke-control system panel.
 - 2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
 - 3. Smoke dampers in air ducts of designated HVAC duct systems.
 - 4. Magnetically held-open doors.
 - 5. Electronically locked doors and access gates.
 - 6. Alarm-initiating connection to elevator recall system and components.
 - 7. Alarm-initiating connection to activate emergency lighting control.
 - 8. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
 - 9. Supervisory connections at valve supervisory switches.
 - 10. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
 - 11. Supervisory connections at elevator shunt-trip breaker.
 - 12. Data communication circuits for connection to building management system.
 - 13. Data communication circuits for connection to mass notification system.
 - 14. Supervisory connections at fire-extinguisher locations.

3.8 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."
- B. Install framed instructions in location visible from FACU.

3.9 GROUNDING

- A. Ground FACU and associated circuits in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Ground shielded cables at control panel location only. Insulate shield at device location.

3.10 FIELD QUALITY CONTROL

- A. Field tests must be witnessed by authorities having jurisdiction.

B. Administrant for Tests and Inspections:

1. Owner will engage qualified testing agency to administer and perform tests and inspections.
2. Engage qualified testing agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

C. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.
 - a. Inspection must be based on completed record Drawings and system documentation that is required by "Completion Documents, Preparation" table in "Documentation" section of "Fundamentals" chapter in NFPA 72.
 - b. Comply with "Visual Inspection Frequencies" table in "Inspection" section of "Inspection, Testing and Maintenance" chapter in NFPA 72; retain "Initial/Reacceptance" column and list only installed components.
2. System Testing: Comply with "Test Methods" table in "Testing" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for public operating mode in accordance with manufacturer's written instructions. Perform test using portable sound-level meter complying with Type 2 requirements in ASA S1.4 Part 1/IEC 61672-1.
4. Test audible appliances for private operating mode in accordance with manufacturer's written instructions.
5. Test visible appliances for public operating mode in accordance with manufacturer's written instructions.
6. Factory-authorized service representative must prepare "Fire Alarm System Record of Completion" in "Documentation" section of "Fundamentals" chapter in NFPA 72 and "Inspection and Testing Form" in "Records" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.

D. Reacceptance Testing: Perform reacceptance testing to verify proper operation of added or replaced devices and appliances.

E. Fire-alarm system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

H. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.11 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system. Allow Owner to record training.

3.12 MAINTENANCE

- A. Maintenance Service: Beginning at Substantial Completion, maintenance service must include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies must be manufacturer's authorized replacement parts and supplies.
 - 1. Include visual inspections in accordance with "Visual Inspection Frequencies" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - 2. Perform tests in "Test Methods" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - 3. Perform tests per "Testing Frequencies" table in "Testing" paragraph of "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.13 SOFTWARE SERVICE AGREEMENT

- A. Comply with UL 864.
- B. Technical Support: Beginning at Substantial Completion, service agreement must include software support for two years.
- C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software must include operating system and new or revised licenses for using software.
 - 1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

END OF SECTION

SECTION 31 10 00

SITE CLEARING AND PREPARATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. This section is only a portion of the Contract Documents. All of the Contract Documents, including Conditions of the Contract and Division 1 General Requirements, apply to this section.

1.02 DESCRIPTION OF WORK

- A. Provide all labor, materials, equipment, and services necessary to complete the work of this Section as specified herein, as shown on the drawings, or both. The Contractor shall coordinate site preparation and demolition activities for each phase of construction. Refer to the Drawings for Phasing and items to be salvaged and relocated.
- B. The work of this Section includes, but is not limited to, the following:
 - 1. Staking layout, limits of work and extent of grading
 - 2. Protection of existing improvements to remain
 - 3. Construction fencing and gates
 - 4. Tree protection
 - 5. Clearing and grubbing
 - 6. Stripping, stockpiling and disposing of topsoil
 - 7. Saw cutting existing pavement
 - 8. Removing bituminous concrete pavement
 - 9. Demolition, removal and legal off-site disposal of all existing above grade and subsurface improvements as indicated on the Drawings
 - 10. Salvage items
 - 11. Demolition of Buildings and structures as identified on the Drawings, refer to Building Demolition Specification, Section 024100, and Record Drawings of Original Construction.
- C. Sustainable Building Requirements:
 - 1. The Contractor is to implement practices and procedures to meet the project's sustainable performance goals, which include achieving LEED v4 Silver certification

SITE CLEARING AND PREPARATION

based on USGBC's "LEED Version 4 for Building Design and Construction: Schools" (LEED v4 BD+C: Schools).

2. The work of this Section includes responding to Architect or Contractor requests for additional information or product data and may be required following initial Green Building Certification Institute (GBCI) review of LEED Application.
3. Product substitution requests are subject to additional LEED submittal requirements including, but not limited to, Environmental Product Declarations (EPD), Health Product Declarations (HPD), and General Emissions Testing.

1.03 RELATED WORK

- A. Carefully examine all of the Contract Documents for requirements that affect the work of this Section. Other specification sections that directly relate to the work of this Section include, but are not limited to, the following:
 1. Document 003100 – Available Project Information.
 2. Section 015000 – Temporary Facilities.
 3. Section 015700 – Temporary Controls.
 4. Section 023000 – Subsurface Investigation.
 5. Section 024100 – Demolition.
 6. Section 028313 – Hazardous materials Handling and Disposal.
 7. Section 260000 – Electrical.
 8. Section 312000 – Earth Moving.
 9. Section 312500 – Erosion and Sedimentation Controls.
 10. Section 330130 – Relining Sewer and Drain Lines.

1.04 PROJECT CONDITIONS

- A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional cost will be allowed because of lack of full knowledge of existing conditions.
- B. Preparation and Workmanship: Except as otherwise specified, site preparation, demolition work and clean up shall be the work of the Contractor. Any item of work not specifically designed to be accomplished by a particular subcontractor shall be considered work of the Contractor.
- C. Traffic: Conduct site clearing and demolition operations to ensure minimum interference with roads, streets, walks, and other adjacent occupied or used facilities. Do not close or obstruct streets, walks or other occupied or used facilities without permission from authorities having jurisdiction.
- D. Protection of Existing Improvements: Provide protection necessary to prevent damage to existing buildings, paving, services and all other improvements indicated to remain in place. Locate and identify existing underground utilities within project limit lines. Provide adequate means of protection of all utilities to remain. The Contractor shall contact "Dig-Safe" at 1-888-344-7233 prior to beginning any excavation work. The Contractor shall be solely responsible for locating all underground utilities prior to the commencement of work. Locations of existing utilities on the site plans are not warranted to show all existing utilities under or above ground. Existing utilities indicated on the site plans are shown only for the convenience of the Owner's

representatives.

1. Protect improvements and surfacing on Owner's property.
 2. Restore improvements damaged during construction to their original condition, as acceptable to the Owner and any agencies having jurisdiction.
- E. Protection of existing Trees and Vegetation: Protect existing trees and other vegetation indicated to remain in place, against unnecessary cutting, breaking or skinning of roots, skinning or bruising of bark, smothering of trees by stockpiling construction materials or excavated materials within drip line, damaging heat from paving equipment, excess foot or vehicular traffic, or parking of vehicles within tree canopy drip lines. Provide temporary guards, fencing or any other necessary precautions to protect trees and vegetation to remain.
1. Water trees and other vegetation via off site supply or other legal methods in the event of a water ban to remain within limits of contract work to maintain their health during the course of construction operations.
 2. Repair trees and vegetation indicated to remain that are damaged by construction operations, in a manner acceptable to the Architect. Employ a licensed arborist to repair damage to trees and shrubs.
 3. Replace trees and vegetation that cannot be repaired and restored to full-growth status, as determined by a licensed arborist. Trees determined to be removed due to damage caused by the work of this project shall be removed and replaced at the Contractor's expense with a quantity of approved tree species that match the total tree caliper surface area of the removed trees as measured 12-inches above original grade. Damage requiring tree removal (coordinate with grading plan) shall include damage to roots, trunk or branches where protection would have prevented such damage. The extent of damage requiring tree removal shall include any one or more of the following: permanent scarring of tree bark, loss of branches or portions of branches that disfigure the tree character, compaction or material contamination of the root zone, damage to roots beyond excavation payment lines, irreversible decline in tree health due to lack of watering.
- F. Dust and Pollution Control: Provide dust control for dust generated by the work of this project. Dampen surface or use other approved method. Comply with pollution control requirements of the Town of Wakefield Board of Health.
- G. Salvageable Improvements: Carefully remove items indicated to be salvaged or reused, and store at the site at an approved location for future use. Protect such items from accidental damage, vandalism and theft.
- H. Bench Marks: Locate, protect and maintain bench marks, monuments, control points and project engineering reference points.
- I. Regulatory controls: All work within this Section must comply with the requirements of all authorities having jurisdiction.
- J. Subsurface conditions:

1. Refer to Document 003100 – AVAILABLE PROJECT INFORMATION (Geotechnical report , Hazardous Material Summary Report)
2. Section 023000 – SUBSURFACE INVESTIGATION.

PART 2 - PRODUCTS

2.01 TREE PROTECTION

- A. Materials for tree protection shall be:
 1. Pressure treated southern yellow pine wood posts
 2. Spruce or fir wood rails
 3. Orange plastic construction safety fence
 4. Galvanized hardware

2.02 TEMPORARY CONSTRUCTION FENCE

- A. Temporary Construction Fence shall be six-foot high galvanized chain link steel fence panels on stable, movable footings and include hardware to secure panels together. Where panels are used as gates, provide chain and padlock to secure when site is closed. There shall be no visible gaps between panels or below.
- B. The Contractor shall furnish safety signage for the perimeter construction fence of the type, size and spacing required by applicable safety standards and "CLOSED FOR CONSTRUCTION" or similar signage.
- C. Placement of temporary construction fence to comply with OSHA standards and not to interfere with ADA requirements.

PART 3 - EXECUTION

3.01 SITE ENGINEERING /LAYOUT

- A. Prior to the start of clearing and excavation operations, lay out and stake the new building, paved areas, limits of cut and fill and work limit lines for the Architect's review.
- B. Promptly upon completion of layout work, and before any clearing or other construction work is begun, the Contractor shall arrange a conference on the site with the Architect to review the limits of work areas staked out. The limit of cut and fill shall be clearly marked to determine the extents of tree removal required.

3.02 TREE PROTECTION

- A. Prior to starting any construction work, erect tree protection in accordance with the Detail where shown and as directed by the Architect in the field.

- B. Within the limit of work, protect all plant materials to remain. No such plant materials shall be used as guys or other fastenings. No material storage, vehicle parking or access routes shall occur under the dripline of trees to remain except where work is specifically shown on the Drawings.
- C. The Contractor shall not cause any damage to trees to remain. If the limits of excavation defined by the Contract Documents require removal of roots of trees to remain, such roots (coordinate feasibility with grading plan) shall be neatly cut after consulting with an Arborist and notifying the Architect.

3.03 TEMPORARY CONSTRUCTION FENCE

- A. Review layout for temporary construction fencing with the Owner and in coordination with the erosion control installation prior to installation of the construction fence. Coordinate gate locations and lock system with the Owner and Wakefield Police and Fire Departments.
- B. The Contractor shall install safety signage for the perimeter construction fence and "CLOSED FOR CONSTRUCTION" or similar signage on construction fence at all points where the fencing abuts pathways and driveways.
- C. Relocate temporary construction fencing as required to perform the work and to maintain unobstructed access through the Owner-occupied portion of the site.
- D. Remove temporary construction fence and associated footings and hardware only after the work has been accepted, including landscape establishment.

3.04 CLEARING AND GRUBBING

- A. After the Landscape Architect has reviewed the limit of clearing, remove trees and shrubs as indicated on the Drawings to construct the work of this project.
- B. Grubbing: Completely remove stumps and roots of vegetation indicated to be removed.
- C. All materials from clearing operations shall be removed from the site prior to or by the end of the clearing operations. On-site disposal will not be allowed.
- D. Fill holes, depressions caused by clearing and grubbing operations with fill material and placement conforming to Section 312000 – EARTH MOVING as specified for the proposed improvements. Place fill in horizontal layers, 6 inches in loose depth, and compact to the specified density.
- E. Without exception, any area cleared for any reason by the Contractor, inside or outside the Limit of Work Line and not otherwise developed shall be loamed and seeded at no additional cost to the Owner.
- F. Tree clearing shall include as many separate mobilizations by the Contractor's sequence of operations due to the phased nature of the project. A selective clearing operation shall be performed by the Contractor after rough grading has been completed, to remove trees, stumps and vegetation at the limits of cuts and fills as directed by the Architect in the field.

3.05 STRIPPING AND DISPOSING OF TOPSOIL

- A. Prior to the start of General Excavation, strip all topsoil and subsoil from within areas to be re-graded, disposing of stripped material in accordance with applicable regulations. Do not commence the stripping operation without a clear understanding of the existing soil depths, planting and site conditions to be preserved and limits of topsoil stockpile and stripped areas.
- B. All topsoil encountered during the stripping operations, regardless of depth, shall be removed and stockpiled for re-use onsite. Refer to Section 319100-Loam and Planting Preparation for information regarding the existing topsoil and requirements for new planting soils. Areas having greater depths of topsoil than indicated on boring data sheets or reasonably anticipated shall be stripped of all such material and fill shall be used to bring such areas to the rough grade level. Stones over six inches and tree roots over two inches in any dimension shall be removed from loam before stockpiling. Stripped soil that can be classified as fill as defined in Section 312000 – EARTH MOVING, shall be stockpiled for reuse in rough grading. This material shall be stripped separately from the topsoil.
- C. The Contractor shall control the stripping operation so that the topsoil does not become contaminated with subsoil or other earth materials. The Contractor shall use machinery suitable for achieving this result.
- D. Subsoil: The material directly below the topsoil indicated on the test pit logs as "subsoil" shall not be considered usable as Ordinary Fill as specified in Section 312000 – EARTH MOVING or for topsoil. The only area where subsoil may be used is under areas with new landscape planting. Subsoil shall be stripped separately from the topsoil and from the underlying earth materials. Subsoil shall be stripped as follows:
 - 1. Building Structures, Roads, Parking Areas, Paved Walkways and other site improvements except lawn areas - remove completely to a depth of eighteen inches (18") below the site improvement as noted in Section 312000-EARTH MOVING subsection 3.4-K and 3.4-L.
 - 2. Future Lawn Areas - not necessary to remove in fill condition. However, subsoil shall be removed from adjacent proposed buildings, structures, site improvements, roads and parking areas a distance equal to the depth of fill plus three feet in the particular location, i.e. for a five foot fill, subsoil shall be removed a minimum of eight feet away from the adjacent site improvements.
- E. All excess subsoil encountered in earthwork operations shall be removed from the site and legally disposed of. Topsoil shall be stockpiled as described hereinabove.

3.06 BITUMINOUS CONCRETE

- A. Remove and legally dispose of all bituminous concrete paving indicated on the Drawings to be removed and all other paving required to be removed in order to construct the Project.
- B. Saw cut existing bituminous paving at all locations where pavement to be removed or pulverized meets existing pavement to remain and where new pavement meets existing pavement to remain. Sawcuts shall be made with sharp tools and blades to provide a clean, straight and vertical cut line. Use carbide or other type blade intended

for that purpose.

- C. Reclaimed Base Course – Pulverize and Blend: In existing bituminous paved areas that will be paved with new bituminous concrete as part of the work of this project, the existing bituminous pavement shall be uniformly crushed, pulverized and blended with the underlying gravel base.
1. The final mixture (asphalt surface and aggregate base course material) shall be pulverized such that the resulting material will be free from excessive fine material.
 - 100% passes the 3-inch (75mm) sieve.
 - 95% passes the 2-inch (50mm) sieve.
 - 55% passes the Number-4 (4.75mm) sieve.
 - Material passing the Number-200 sieve not to exceed 8% by weight.
 2. Prior to pulverizing the existing pavement, the Contractor shall locate and protect existing utility structures and underground pipes, culverts, conduits and other appurtenances to remain. If the upper sections of utilities are removed to facilitate pulverizing the existing pavement, the remaining part of the structure designated to remain shall be immediately covered with a steel plate capable of withstanding a 36.5 ton truckload with impact.
 3. The Contractor shall submit to the Architect for approval a description of equipment and the process to be used for pulverizing and blending the existing pavement (Full-Depth Reclamation).
 4. Full-depth reclamation (FDR) shall consist of uniformly crushing, pulverizing and mixing existing asphalt pavement and the underlying base course material to depths as shown in the drawings. This work shall conform to The Commonwealth of Massachusetts Department of Transportation, Standard Specifications for Highways and Bridges, latest edition Section 403 Reclaimed Base Course.
 5. The material produced shall be a homogeneous mass that is able to be placed, compacted and cured; and conformed to the lines, grades, thickness and typical cross sections as shown in documents.
 6. FDR shall consist of the existing asphalt pavement and existing base course material. The base course material shall not contain roots, clay, bricks, topsoil or deleterious material.
 7. No more than 50% of the final mixture shall be made of the existing asphalt pavement unless approved by the engineer or Owner.
 8. Reclamation shall be accomplished by means of self-propelled, traveling rotary reclaimer or equivalent machine capable of cutting through existing asphalt pavement to depths up to 12-inches in one pass. Existing asphalt pavement and underlying aggregate base course material must be pulverized and mixed to form a homogeneous mass. The Contractor shall submit a description of the equipment and process to be used for pulverizing and blending the existing pavement.

9. FDR processing shall not commence during frozen or saturated conditions. Moisture in the base course material shall be within +/-2% of the optimal moisture content for the processed material.

3.07 ABOVE AND BELOW GRADE IMPROVEMENTS

- A. Remove and legally dispose of all existing above and below grade improvements necessary to allow construction of all work of this Contract including but not limited to outbuildings and associated foundations, pipes, tanks, concrete slabs, castings, curbing, walls, fencing, signage and any and all other improvements inside or outside the contract limits except items indicated on the Site Preparation Plan to be preserved and protected or removed and salvaged. Remove walls, footings, and other obstructions to a depth of at least 2 feet below finished grades to construct the subsurface improvements of this project.
- B. Abandonment, relocation, partial removal or complete removal of certain existing underground and above ground utilities including, but not limited to pipes, tanks, castings, conduits, electrical wiring and poles shall be performed as indicated on the Drawings.

3.08 SALVAGE ITEMS

- A. The Drawings depict specific items to be salvaged and relocated in the new design. The Contractor shall review these items in person with the Architect prior to any site demolition in these areas.
- B. Salvaged items shall be carefully removed, cleaned and stored in a protected area, undamaged until the new site conditions are prepared for their reinstallation. Salvaged items include but are not limited to:
 1. Signage removed by work of this contract shall be salvaged and provided to the Owner. Footings shall be removed and disposed.

3.09 DISPOSAL OF WASTE MATERIALS

- A. Removal from Owner's property: Remove all waste materials from Owner's property in timely and responsible manner and legally dispose of off-site. Accumulation is not permitted. Maintain disposal routes clear, clean and free of debris. Dumping and / or burning of material on site will not be permitted.

3.10 CLEAN UP

- A. Keep pavements and areas adjacent to and leading from the site, clean and free of mud, dirt and debris.
- B. At completion of the work of this Section, remove materials generated by site clearing. Do not spill or disperse debris on the site. Leave the site in a safe and clean condition acceptable to the Architect.

END OF SECTION

FSECTION 31 20 00

EARTH MOVING

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

- A. The General Documents, as listed in the Table of Contents, and applicable parts of Division 1, GENERAL REQUIREMENTS, shall be included in and made a part of this Section.
- B. Examine all drawings and all other Sections of the Specifications for the requirements therein affecting the work of this trade. Plans, surveys, measurements, and dimensions, under which the work is to be performed are believed to be correct to the best of the Architect's knowledge, but the Contractor shall have examined them for himself during the bidding period, as no allowance will be made for any errors or inaccuracies that may be found herein. The contractor shall reconcile all drawings.
- C. Where there is a conflict between drawings, the stricter requirement shall be adopted at no additional cost to the owner.
- D. The Contractor shall become thoroughly familiar with the site, thoroughly review bid documents, consult records and drawings of adjacent structures and of existing utilities and their connections, and note all conditions which may influence the work of this Section.
- E. By submitting a bid, the Contractor affirms that he has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of lack of full knowledge and understanding of the bid documents.
- F. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to assure a steady progress of work under this Contract.

1.2 SCOPE OF WORK

- A. Other than unanticipated site conditions, the Work described in Section 1.2 of these specifications shall be included in the base bid and will not be paid for separately. Other than unanticipated site conditions, the
- B. The work of this section consists of all excavation, filling and grading and related items as indicated on the Drawings and/or as specified herein and includes, but is not limited to, the following:
 - 1. All materials, equipment, labor, and services required for all Earth Moving work, including all items incidental thereto, as specified herein and as shown on the Drawings.
 - 2. Excavation of all types, including but not limited to excavations for footings, slabs, foundations, retaining walls, temporary support of excavations, dewatering systems, new pavements, ramps, equipment pads, curbs, sidewalks, and utilities, to the lines and grades shown in the Drawings or the limits specified herein, whichever is deeper. The excavation includes rock removal as necessary to allow the construction of foundations, slabs on-grade, and installations

of utilities. Excavation shall include removal and legal offsite disposal of all materials that cannot be reused. The contractor shall estimate quantities of cuts and fill. Such quantities shall be included in the base bid.

3. Excavating, filling, trenching, backfilling, compaction, and concrete encasement of utility conduits, of all description, required for the construction of foundations, walls, building structures, retaining walls, temporary support of excavations, dewatering systems, new pavements, ramps, equipment pads, curbs, sidewalks, utility structures, lawn areas, and site improvements. Provide all additional fill materials as required and specified herein. Refer to Sections on Heating, Plumbing, Fire Protection, Electrical and Structural for other excavation.
4. The Work of this Section shall include performance of pre and post blasting surveys, preparation of a blast design plan and analysis, and provision of all services in accordance with requirements of 527 CMR 13.00 Explosives and the Contract Documents, for all existing building structures and utilities located within 250 feet of the Limit of Work Line (LOW) as indicated on the Drawings. The Contractor shall coordinate with the Town of Wakefield Fire Department to provide fire watch services before, during, and after all blasting performed under the Contract, in accordance with requirements of 527 CMR 13.00 Explosives and the Contract Documents. The Contractor shall obtain all required permit to transport, store, and use explosives at the site. Rock blasting operations shall not start until all required permits are obtained by the Contractor.
5. Removing rock by means of blasting within the proposed building footprint, access roadways, and retaining walls, add utility trenches. Rock removal is anticipated at the site, including but not limited the proposed building footprint and along the access road from Farm Street.
6. Performing pre- and post-blast surveys and vibration monitoring.
7. Installing rock dowels, slope drainage in rock, and performing rock slope scaling.
8. Entirely removing unsuitable material as necessary, and other deleterious matter from within the proposed building footprint.
9. Entirely removing unsuitable material as necessary, and other deleterious material from within the proposed paved areas.
10. Improving the existing fill under the subbase of paved areas.
11. Screening and stockpiling the topsoil for reuse as directed by the Architect.
12. Performing test pits before start and during construction as required by the Geotechnical Engineer. For cost estimating purposes, the Contractor shall include one (1) days of test pits at the start of earth moving operations, and at least 5 half days of test pits throughout the earth moving operations.
13. Removing and disposing of spoiled material not suitable for fill from the site. No burning on the site shall be permitted.
14. Processing excavated soils free of organic matter, boulders, and blasted rock, by rushing and blending as needed, to produce materials meeting the specifications herein.
15. Rehandling, hauling and placing of stockpiled materials for use in refilling, filling, backfilling, grading and such other operations. Stockpiling shall include protection to maintain materials in a workable condition.
16. Furnishing, placing, and compacting fill materials, Including subbase layer under paved areas, ramps, equipment pads, curbs, sidewalks, and other locations required in the drawings.
17. Removing, hauling, stockpiling, rehandling, and placement of materials.
18. Over-excavation to remove unsuitable materials.
19. Proofrolling/proofcompacting of exposed subgrade for fill, footings, foundations, slabs, walks, equipment pads, pavements, lawns and grasses, and exterior plants.

20. Backfilling of excavations for foundations, footings, walls, utilities, pavements, sidewalks, and landscaped areas with specified on-site and imported materials.
 21. Installing at Contractor's cost seismographs and monitoring vibration at the nearby existing buildings during construction. The cost of vibration monitoring shall be included in the base bid. The Contractor shall include at least four (4) seismographs throughout the duration of the earthwork operations and shall submit the data weekly or when an exceedance occurs, whichever occurs first.
 22. Disposing off-site of excess or unsuitable materials.
 23. Placing bedding, sub-base and base course layers.
 24. Stabilizing/mitigating of saturated or otherwise disturbed materials.
 25. Performing rough and final grading.
 26. Filling slopes and site retaining walls.
 27. Installing and removing, as needed, excavation support, shoring or bracing as necessary to perform the excavations during the removal of the unsuitable materials. Excavation support system may be left in place where approved by the Owner.
 28. Protecting existing buildings, utilities, roads, pavements, lawns, planting, and other improvements from damage due to construction.
 29. Performing coordination of material testing shall be the responsibility of the Contractor. All imported material tested shall be under ASTM D422 and shall be paid for by the Contractor.
 30. Performing material testing, and field density testing as needed.
 31. Performing dust control and cleanup throughout earth moving operations.
 32. Groundwater Control, dewatering, pumping, bailing and control of groundwater and surface water for all work under this contract in accordance with item 1.13 of these specifications.
 33. Installing temporary support of excavation as needed in accordance with item 1.12 of these specifications.
 34. Installing fencing and safety devices or controls as specified and as necessary.
 35. Notifying all affected utility companies, Dig Safe, Owner Representative, and authorities having jurisdiction over the work before the start of work.
- B. The Work of this Section shall include performance of pre and post construction Condition surveys of building and structures within 250 feet of nearest earth moving activity.

1.3 CONTRACT REFERENCE

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections
 1. Section 01 56 39, Temporary Tree and Plant Protection
 2. Section 03 30 00, Cast-In-Place Concrete
 3. Section 22 00 00, Plumbing
 4. Section 31 10 00, Site Clearing and Preparation
 5. Section 32 18 23, Synthetic Turf
 6. Section 31 25 00, Erosion and Sedimentation Controls
 7. Section 32 12 16, Asphalt Paving

- 8. Section 32 13 13, Exterior Concrete
- 9. Section 32 16 00, Curbing
- 10. Section 32 30 00, Site Improvements
- 11. Section 32 32 00 Gravity Block Retaining Wall
- 12. Section 32 91 00, Loam and Planting Preparation
- 13. Section 33 10 00, Water Utilities
- 14. Section 33 30 00, Sanitary Sewage Utilities
- 15. Section 33 40 00, Storm Drainage Utilities

1.4 DESCRIPTION

- A. The Contractor shall furnish all labor, material, tools, and equipment necessary to excavate materials; segregate, track, handle, sample, analyze, and test excavated materials, backfill, and re-grade as indicated on the Drawings.
- B. The Contractor shall use suitable on-site soils and fill that meet the requirements of these specifications, and soil from off-site sources, as needed. Please note that most of the on-site existing subsoil, fill, and natural soil will likely not be suitable for reuse without amending/blending/processing. The contractor shall avoid mixing the reusable soils with fine-grained and/or organic soils. Imported materials or amending/blending/processing of onsite materials are anticipated for this project. The Contractor is encouraged to process onsite soils with blasted rock to produce materials meeting the requirements of these specifications
- C. The Contractor shall make excavations in such a manner and to such widths that will provide suitable room for performing the Work and shall furnish and place all sheeting, bracing, and supports as necessary. Excavation support is anticipated for this project.
- D. The Contractor shall provide labor and material for all pumping and draining, as necessary; and shall render the bottom of excavation firm and dry and in all respects acceptable. The Contractor shall collect and properly dispose of all discharge water from dewatering systems in accordance with local and State requirements and permits.
- E. The Contractor shall raise the Site to final grades and compact the subgrade and intermediate layers to the required criteria set forth within this Section of the Construction Specifications.
- F. The Contractor shall provide routine monitoring of in-place excavation support system.
- G. The Contractor shall protect and moisture condition all onsite and imported materials for proper installation, compaction and use. This includes covering, drying, and adding moisture in order to maintain suitable workability of the soil materials. Failure by the Contractor to follow this requirement shall not be cause for additional cost to the Owner.

1.5 INFORMATION:

- A. Information on the Drawings, Reference Drawings, Geotechnical Reports, and in the Specifications relating to subsurface conditions, natural phenomena, and existing utilities and structures is from the best sources presently available. Such information is furnished only for information and is not guaranteed.

- B. Site Information – Data on indicated subsurface conditions are not intended as representations or warrants of continuity of such conditions between soil borings and test pits. It is expressly understood that the Owner will not be responsible for interpretations or conclusions drawn there by the Contractor. Data is made available for the convenience of the Contractor.
- C. The Contractor, at his/her own expense, may conduct additional subsurface testing for his/her own information after approval by the Owner. The Owner assumes no responsibility for the Contractor's failure to make his own site investigation and makes no representation other than the soils reports regarding the character of the soil or subsurface conditions which may be encountered during the performance of the work. The Contractor shall refer to the Geotechnical Report. Failure by the Contractor to be aware of existing site conditions shall not be cause for additional cost to the Owner.

1.6 SUBSURFACE CONDITIONS AND SPECIAL SITE CONSIDERATIONS

- A. Lahlaf Geotechnical Consulting, Inc. of 100 Chelmsford Road, Suite 2, Billerica, MA 01862 prepared a geotechnical report titled: "Geotechnical Report, Proposed Northeast Metropolitan Regional Vocational Technical High School, Wakefield, Massachusetts, dated November 16, 2022. The Owner, the Architect, and the Geotechnical Engineer make no representation other than the soils reports regarding the character of the soil or subsurface conditions which may be encountered during the performance of the work. Failure by the Contractor to be aware of existing site conditions shall not be cause for additional cost to the Owner.
- B. Information on subsurface conditions is made available for the convenience of the Bidders. Bidders are invited to review the information to apprise themselves of the information available, and also, if they deem necessary, to make additional investigations at their own expense.
- C. Interpretation of this data for purposes of construction is the responsibility of the Contractor. It is the Contractor's responsibility to make interpretations and draw conclusions with respect to the character of materials to be encountered and groundwater conditions at the site and their impact upon Contractor's work based on his expert knowledge of the area, construction dewatering methods, and support of excavation methods. Contractor may, at his own expense, conduct additional subsurface testing as required for his own information after approval by the Owner.
- D. The Geotechnical Report indicates that the majority of the materials present at the site contain quantities of fines beyond the limit deemed acceptable for reuse by the specification. The contractor is made aware of this condition and will not be eligible to receive additional compensation exceeding the Contractor's initial bid for imported material.
- E. The Contractor shall visit the site prior to submitting a bid to become familiar with the extent of the work to be done under this Contract. The Contractor shall be responsible for determining the quantities of earth materials necessary to complete the work under this Section. All earth materials shall be included in the Contractor's base bid.
- F. Test boring and test pit locations as depicted on the Drawings are located by tape measurements from existing site features and structures and shall only be considered as accurate as the procedure utilized.
- G. The Contractor shall be aware that the ground surface elevation was interpolated to the nearest foot and are approximate.
- H. No claim for extra cost or extension of time resulting from reliance by the Contractor on information presented herein shall be allowed, except as provided in the Contract Documents.

1.7 QUALITY CONTROL

- A. Costs related to retesting due to unacceptable quality of work and failures discovered by testing shall be paid for by the Contractor at no additional expense to Owner, and the costs thereof will be deducted by the Owner from the Contract Sum.

1.8 COORDINATION

- A. Prior to start of earthwork, the Contractor shall arrange an onsite meeting with the Architect, Engineer, the Geotechnical Engineer, and the site testing agency for the purpose of establishing the Contractor's schedule of operations, discussing activities that need to be observed by the Geotechnical Engineer, and scheduling observation and testing procedures and requirements.
- B. As construction proceeds, the Contractor shall be responsible for notifying the Geotechnical Engineer at least 2 days and the site testing agency at least 24 hours prior to the start of earthwork operations requiring observation and/or testing. This section also applies to instances when the General Contractor resumes earthwork operations after a period of pause in earthwork operations that require observations by the Geotechnical Engineer.
- C. The work of this Section shall be coordinated with that of other trades affecting, or affected by, this work, as necessary to ensure the steady progress of all work of the Contract.

1.9 PERMITS, CODES AND SAFETY REQUIREMENTS

- A. This project is subject to the Safety and Health regulations of the U.S. Department of Labor set forth in 29 CFR, Part 1926. Contractors shall be familiar with the requirements of these regulations and with the Supplemental General Conditions on Safety for this project.
- B. The Contractor is responsible for the adequacy of the excavation support system and shall retain the services of a Professional Engineer registered in Massachusetts to design any required excavation support systems. The Contractor's Professional Engineer shall practice in a discipline applicable to excavation work, shall have experience in the design of excavation support systems and shall design in conformance with OSHA requirements. The Contractor's Professional Engineer shall provide sufficient on-site inspection and supervision to assure that the excavation support system is installed and functions in accordance with his design. Criteria listed herein defining the responsibilities of the Contractor's Professional Engineer are minimum requirements.
- C. All work shall conform to the Drawings and Specifications and shall comply with applicable codes and regulations.
- D. Comply with the rules, regulations, laws, and ordinances of the Town of Wakefield, of the State of Massachusetts, appropriate agencies of the State of Massachusetts and all other authorities having jurisdiction. Coordinate all work done within Town and State rights of way with the appropriate agencies. Provide all required traffic control and safety measures, including uniformed police officers per Town and State requirements. All labor, materials, equipment and services necessary to make the work comply with such requirements shall be provided without additional cost to the Owner.
- E. Comply with the provisions of the Manual of Accident Prevention in Construction of the Associated General Contractors of America, Inc., and the requirements of the Occupational Safety and Health Administration (OSHA), United States Department of Labor whichever is more stringent.

- F. The Contractor shall procure and pay for all permits and licenses required for the complete work specified herein and shown on the Drawings.
- G. The Contractor shall not close or obstruct any street, sidewalk, or passageway unless authorized in writing by the Architect. The Contractor shall so conduct his operations as to interfere as little as possible with the use ordinarily made of roads, driveways, sidewalks, or other facilities near enough to the work to be affected hereby. The Contractor shall comply with the time limits established by the terms for trucking onto and off the site.
- H. Any apparent conflict between the Drawings and Specifications and the applicable codes and regulations shall be referred to the Architect in writing, for resolution before the work is started.
- I. The Contractor shall comply with all excavation, trenching, and related sheeting and bracing requirements of Occupational Safety and Health Administration (OSHA) excavation safety standards, 29 CFR Part 1926.650 through 1926.652.
- J. The Contractor is responsible for compliance with the conditions listed in the order of Conditions issued by the Wakefield Conservation Commission.

1.10 LAYOUTS AND GRADES

- A. All line and grade work not presently established at the site shall be laid out by a survey team under the supervision of a Land Surveyor or Professional Engineer registered in the Commonwealth of Massachusetts and employed by the Contractor in accordance with Drawings and Specifications. Basic layout for the project is shown on the drawings. The Contractor shall supply all additional layout and grade control as necessary to properly implement and construct the work. The Contractor shall establish permanent benchmarks and replace as directed any which are destroyed or disturbed. The Contractor shall employ and pay all costs for a registered Civil Engineer or Surveyor who is licensed within the jurisdiction of the project site to lay out all lines and grades in accordance with the Drawings and Specifications, and as necessary or required for the construction. The Contractor shall submit building layout drawings for approval, stamped by a Registered Surveyor.
- B. The words "finished grades" as used herein shall mean final grade elevations indicated on the Drawings. Spot elevations shall govern over proposed contours. Where not otherwise indicated, project site areas outside of the building shall be given uniform slopes between points for which finished grades are indicated or between such points and existing established grades.
- C. The word "subgrade" as used herein, means the surface or elevation remaining after completing excavation or top surface of a fill, borrow fill or compacted fill. This surface is immediately beneath the site improvements, fill materials as dimensioned on the Drawings, or other proposed surface material.
- D. The words "rough grading" shall mean excavating or filling to elevations indicated, and to the required depths herein. The permissible tolerance of rough grading within an area 100 sq. ft. shall not exceed plus or minus 2 in. The cost of placing fill material to refill areas having rough grades lower than designed shall be borne by the Contractor.

1.11 DISPOSITION OF EXISTING UTILITIES

- A. All work shall be executed in such a manner as to prevent any damage to existing buildings, streets, curbs, paving, service utility lines, structures, and adjoining property. Existing streets, sidewalks

and curbs damaged during the project work shall be repaired or replaced to their condition prior to commencement of Earth Moving operations.

- B. Locate and mark underground utilities to remain in service before beginning the work. Active utilities existing on the site and work areas shall be carefully protected from damage and relocated or removed as necessitated by the work. When an active utility line is exposed during construction, its location and elevation shall be plotted on the record drawings as described in this Section and both Architect and Utility Owner notified in writing.
- C. Inactive or abandoned utilities encountered during construction operations shall be removed and suitably backfilled if within the building area. Abandoned utilities outside the building area shall be removed, grouted, plugged, or capped. The location of such utilities shall be noted on the record drawings and reported in writing to the Architect.
- D. The Contractor shall notify "Dig Safe" and local utility companies prior to the start of construction. The "Dig Safe" number shall be submitted by the Contractor in writing to the Architect prior to construction.
- E. Acceptance of any of the Contractor's plans, design calculations and methods of construction by the Designer and /or design team shall not relieve the Contractor of the responsibility for the adequacy of the excavation lateral support system; preventing damage to existing or new structures, utilities and streets adjacent to excavations; the safety of persons working within excavated areas and the public at large; and excavation dewatering.

1.12 SUPPORT OF EXCAVATION

- A. Provide support of excavation (SOE) system, as necessary, in order to meet the requirements of OSHA and to assure complete safety against collapse of earth at sides of excavations. The contractor shall design and submit for review and upon approval install a temporary support of excavation (SOE) to protect the existing structures and utilities during construction and as necessary to perform the excavations during utility excavations and during the removal of the unsuitable materials.
- B. In selecting the type of SOE system, the Contractor shall take into consideration the presence of rock and the presence of cobbles and boulders, and abandoned buried structures in the existing fill and in the natural soil and the presence of shallow bedrock.
- C. If sufficient or proper supports have not been provided, additional supports shall be placed at the expense of the Contractor. Care shall be taken to prevent voids outside of the sheeting, but if voids are formed, they shall be immediately filled and rammed.
- D. All components of SOE system not ordered left in place shall be carefully removed in such a manner as not to endanger the construction of other structures, utilities or property whether public or private. All voids left after withdrawal of sheeting shall be immediately refilled with sand and rammed with tools especially adapted to that purpose or otherwise compacted as directed to achieve the required density.
- E. The design and installation of SOE systems shall not constitute a condition for which an increase may be made in the contract price with the exception that if the Architect directs with writing that certain shoring or sheeting shall be left in place, the contract price will be adjusted in accordance with General Conditions.

- F. SOE systems shall be designed to support the earth pressures, surcharge loads from stored material and construction equipment.
- G. Shoring and bracing of trenches and other excavations shall, at a minimum, be in accordance with the latest requirements of the Department of Labor and Industries Bulletin No. 12, Section 10, and all subsequent amendments, and OSHA excavation safety standards.
- H. SOE systems shall be designed by a Professional Engineer registered in the Commonwealth of Massachusetts and hired by and paid for by the Contractor.

1.13 DRAINAGE AND GROUNDWATER CONTROL

- A. The Contractor shall control the grading in areas under construction at the site so that the surface of the ground will properly slope to prevent accumulation of groundwater and surface water in excavated areas and adjacent properties.
- B. Contractor is cautioned that excavation in rock within the proposed building footprint and within proposed roadway and retaining walls will require extensive dewatering. Provisions shall be made to collect, channel, and legally dispose of the groundwater during construction.
- C. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.
- D. The Contractor shall provide, at his own expense, adequate pumping and drainage facilities to maintain the excavated area sufficiently dry from groundwater and/or surface runoff so as not to adversely affect construction procedures nor cause excessive disturbance of underlying natural ground. The flows of all water resulting from pumping shall be managed so as not to cause erosion, siltation of drainage systems, or damage to adjacent property.
- E. Before excavation below groundwater level, place system into operation to lower groundwater level to specified levels and then operate it continuously until drains, sewers, and structures have been constructed and fill materials have been placed, or until dewatering is no longer required. The groundwater level shall be maintained at 12 inches beneath the bottom of excavation or deeper until the excavation is backfilled to at least 2 feet above the groundwater level. The Contractor shall be prepared to install multiple sump pumps as needed to achieve the requirements of these specifications.
- F. The Contractor shall submit a groundwater control plan in accordance with the requirements of Section 1.19. The plan shall include location of deep and shallow (moveable) sump pumps.
- G. Sump pumps shall be installed in crushed stone wrapped a geotextile fabric for filtration and separation.
- H. Deep stationary sump pumps shall be at least 7 feet beneath the bottom of the deepest excavation, and shallow, moveable sump pumps shall be at least 3 feet beneath the bottom of the excavation.
- I. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.
- J. Damage resulting from the failure of the dewatering operations of the Contractor, and damage resulting from the failure of the Contractor to maintain all the areas of work in a suitable dry condition,

shall be repaired by the Contractor, as directed by the Engineer, at no additional expense to the Owner. The Contractor's pumping and dewatering operations shall be carried out in such a manner as to prevent damage to the Contract work and so that no loss of ground will result from these operations. Precautions shall be taken to protect new work from flooding during storms or from other causes. Pumping shall be continuous to protect the work and/or to maintain satisfactory progress.

- K. All pipelines or structures not stable against uplift during construction or prior to completion shall be thoroughly braced or otherwise protected. Water from the trenches, excavations, and stormwater management operations shall be disposed of in such a manner as to avoid public nuisance, injury to public health or the environment, damage to public or private property, or damage to the work completed or in progress.
- L. The Contractor shall excavate interceptor swales and ditches, as necessary, prior to the start of major earthmoving operations to reduce the potential for erosion and to keep areas as free from surface and ponded water as possible.
- M. All piping exposed above ground surface for this use, shall be properly covered to allow foot traffic and vehicles to pass without obstruction.
- N. Should surface, rain or groundwater be encountered during the operations, the Contractor shall furnish and operate pumps or other equipment and provide all necessary piping to keep all excavations clear of water at all times and shall be responsible for any damage to work or adjacent properties for such water. Protect subgrades and foundation soils from softening and damage by rain or water accumulation. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
- O. The presence of groundwater or stormwater in soil and rock cuts will not constitute a condition for which an increase in the contract price may be made. Under no circumstances place concrete fill, lay piping or install appurtenances in excavation containing free water. Keep utility trenches free of water until pipe joint material has hardened and backfilled to prevent flotation.
- P. Provide standby equipment on-site, installed and available for immediate operation, to maintain dewatering on a continuous basis if any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, restore damaged structures and foundation soils at no additional expense.
- Q. For further information refer to paragraphs on SPECIAL REQUIREMENTS FOR SEQUENCE OF CONSTRUCTION OPERATIONS AND DRAINAGE AND EROSION CONTROL as specified herein.
- R. Remove groundwater control components at end of dewatering operations. Backfill sump pump excavation and plug well hole as applicable using suitable materials as specified herein.

1.14 FROST PROTECTION/WORK IN FREEZING WEATHER

- A. Protect excavation bottoms and sides against freezing. Provide protective insulating materials as necessary, including by means of heat blankets, and heating plant.
- B. A layer of fill shall not be left in an uncompacted state at the close of a day's operation when there is the potential for that layer to freeze.

- C. The Contractor shall not place any material on snow, ice, frozen soil, or soil that was permitted to freeze prior to compaction. Removal of these unsatisfactory materials will be at the Contractor's expense.
- D. Do not excavate to full indicated depth when freezing temperatures may be expected, unless work can be completed to subgrade, the materials installed, and the excavation backfilled the same day. Protect the excavation from frost if placing of materials or backfilling is delayed.
- E. The Contractor shall keep the operations under this Contract clear and free of accumulation of snow within the limits of Contract Lines as necessary to carry out the work. Calcium chloride shall not be used per order of the Conservation Commission.
- F. No materials shall be installed on frozen ground. Fill materials shall be free of frost.
- G. The subgrade of footings and slabs shall be protected from frost before placing concrete. The subgrade on the sides of the footings shall be protected from frost after the footings are constructed until sufficient fill is placed to protect the bottom of footings from frost induced heave. Uninsulated slabs shall be covered with heat blankets during freezing weather. The cover shall extend at least 4 feet beyond the limits of the slabs.

1.15 DISTURBANCE OF EXCAVATED AND FILLED AREAS DURING CONSTRUCTION

- A. The Contractor shall take the necessary steps to avoid disturbance of subgrade and underlying natural soils/compacted fill during excavation and filling operations. Methods of excavation and filling operations shall be revised as necessary to avoid disturbance of the subgrade and underlying natural soils/compacted fill, including restricting the use of certain types of construction equipment and their movement over sensitive or unstable materials. The Contractor shall coordinate with the Architect or Soils Representative to modify his operations as necessary to minimize disturbance and protect bearing soils, based on the Architect's or Soils Representative's observations.
- B. All excavated or filled areas disturbed during construction, all loose or saturated soil, and other areas that will not meet compaction requirements as specified herein shall be removed and replaced with compacted approved material in accordance with this Specifications. Fill that cannot be compacted within 48 hours because of its saturated or wet condition shall be removed and replaced with compacted approved material in accordance with this Specifications. Costs of removal of disturbed material and replacement with approved material shall be borne by the Contractor.
- C. The Contractor shall place a six-inch layer of Crushed Stone or 6-inch layer of Granular Fill/Structural Fill or Crushed Stone over natural soil to stabilize areas disturbed during construction.
 - 1. The placement of the Crushed Stone layer or Granular Fill/Structural Fill as well as material costs shall be borne by the Contractor. A geotextile fabric shall be used to separate the crushed stone from the natural soil when the natural soil is below the groundwater table, and from the overlying fill when directed by the Geotechnical Engineer at no additional cost to the owner.

1.16 SPECIAL REQUIREMENTS FOR SEQUENCE OF CONSTRUCTION OPERATIONS AND DRAINAGE AND EROSION CONTROL

- A. The sequencing of construction operations as specified under Section 31 25 00, Erosion and Sedimentation Controls shall be extended through earthwork operations as follows:
 - 1. Perform initial procedures as specified under Section 31 25 00, Erosion and Sedimentation Controls – Initial Sequence of Construction Activities and Preliminary Drainage Control.

2. Repair any broken or damaged Sections of the haybales or siltation fencing installed during site preparation and install any additional Sections necessary for proper erosion control.
3. Throughout earthwork operations, in addition to drainage swales, check dams, siltation sumps, and other items shown on the Drawings, the Contractor shall take other necessary precautions, including installation of temporary drainage swales, siltation sumps, check dams, haybales, silt fencing and temporary pipe to direct and control drainage from disturbed areas on the site so that erosion and siltation is minimal. In addition, no erosion or discharge of silt or larger particles shall occur in water bodies or wetland areas to remain undisturbed or onto adjacent properties.
4. Damaged or loose haybales and siltation fence shall be replaced as necessary to maintain their function of controlled erosion and siltation. Damaged or broken down check dams and filtration dams shall be replaced immediately.
5. Throughout construction, remove accumulation of silt or soil build-up behind haybales, silt fences, check dams and filtration dams as it occurs. Remove accumulations of silt and build-up from the siltation pumps and silt traps when it is approximately 18 inches deep, or when it adversely affects the performance of the system. Remove silt sacks in catch basins when they have become clogged and replace to maintain their function.
6. Replace the crushed stone on the inside of all siltation sumps as necessary to permit adequate flow through the media and to maintain their function as a filter of silt and larger particles. Excavate silt and other material from the basins of all siltation sumps as it accumulates.
7. Remove temporary drainage swales, check dams, siltation sumps, haybales and other temporary drainage, erosion and siltation control measures when permanent drainage control measures have been installed, and grass is established in drainage areas and lawn areas. Do not remove the above items without approval of the Architect. If, in the Architect's opinion, these measures are still necessary, they shall stay in place.

1.17 DEFINITIONS

- A. Backfill: Soil material used to fill an excavation.
 1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
 2. Final Backfill: Backfill placed over initial backfill to fill a trench.
- B. Base Course: Course placed between the grade and hot-mix asphalt paving.
- C. Bedding Course: Course placed over the excavated subgrade in a trench before laying pipe.
- D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill. Imported fill shall meet the gradation requirements set forth in PART 2 - PRODUCTS.
- E. Building Area: The area defined by the projection of a line from two foot outside of the edge of the footing extending downward and outward at a slope of 1.5H: 1V. (If over-excavation is required below the footing the building area will be redefined from the bottom of over-excavation).
- F. Compaction: The tamping and rolling of all backfill placed in uniform horizontal layers not exceeding a defined uncompacted lift thickness.
- G. Drainage Course: Course supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

- H. Deleterious Material: Trash, debris, clay, topsoil, roots, organic material friable material, glass, material that has become soft and saturated, even if previously compacted, material defined in section 1.17.X, or otherwise degradable materials that compromise the strength and properties of soils.
- I. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
 - 1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions.
 - 2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.
- J. Fill: Soil materials used to raise existing grades or meet proposed grades.
- K. Frost Zone: The area within 4 feet of finished grade.
- L. Influence Zone/Area: The area below a footing defined by the projection of a line from two feet outside of either edge of the footing extending downward and outward at a slope of 1V:1.5H.
- M. "In-the-dry": In-situ soil moisture content of no more than two percentage points above the optimum moisture content for that soil.
- N. Optimum Moisture Content: Determined by the ASTM standard specified to determine the maximum dry density for relative compaction.
- O. Prepared Ground Surface: The ground surface after clearing, grubbing, stripping, excavation, and scarification and/or compaction.
- P. Proof-rolling/proofcompacting: The tamping and rolling of all subgrades including running a loaded rubber tire truck over the subgrade when requested by the Geotechnical Engineer.
- Q. Relative Density: As defined by ASTM D4253 or D4254.
- R. Relative Compaction: The ratio, in percent, of the as-compacted field dry density to the laboratory maximum dry density as determined by ASTM D1557. Corrections for oversized material shall be applied to maximum dry density.
- S. State Standards: Massachusetts Highway Department Standard Specifications for Highways and Bridges.
- T. Structures: Buildings, footings, foundations of any type, retaining walls, buildings and equipment slabs, ramps, stairs, tanks, curbs, sidewalks, mechanical and electrical appurtenances, retaining walls, or other man-made stationary features constructed above or below the ground surface, including utility structures.
- U. Subbase Course: Course placed between the subgrade and base course for hot-mix asphalt pavement, or course placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.
- V. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below structures, subbase, drainage fill, or topsoil materials.

- W. Unclassified Excavation: The nature of materials to be encountered has not been identified or described herein.
- X. Unsuitable material shall be material having at least one of the following properties:
1. Existing fill present with the footprint of proposed buildings and under retaining walls and site structures
 2. Material with a maximum unit dry weight per cubic foot less than 110 lbs., as determined by ASTM D1557.
 3. Material containing greater than 3% organic matter by weight, topsoil, organic silt, peat, construction debris, roots and stumps.
 4. Material which has a Liquid Limit greater than 55 when tested in accordance with ASTM D 4318.
 5. Imported materials or onsite materials slated for reuse that do not meet one of the gradation specifications in this section.
 6. Wet material which cannot be compacted due to moisture contents outside of the limits of ± 2 percentage points of optimum moisture content.
 7. Material classified as unsuitable by the Geotechnical Engineer.
 8. Unsuitable material shall be disposed of off-site as directed by the Architect.
 9. Material processed onsite that is not well graded or contains excess stones and exhibits honeycombing when placed in lifts.
 10. Materials that are unstable as a result of inadequate construction dewatering, excessive subgrade disturbance, or other means and methods used by the Contractor are not considered unsuitable materials. This includes materials that were stable and that have become unstable.
- Y. Utilities: On-site underground and aboveground pipes, conduits, ducts, and cables, as well as underground services within buildings.
- Z. Trench: An excavation of any length where the width is less than twice the depth and where the shortest distance between payment lines does not exceed ten (10') feet. All other excavations shall be defined as open excavations.
- AA. Architect: Where architect is referenced it shall mean the Architect or the Architect's representative.
- BB. Geotechnical Engineer: Where Geotechnical Engineer is referenced it shall mean the Geotechnical Engineer or its representative.

1.18 REFERENCES

- A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements or requirements of other specification sections, the most restrictive requirements that are most favorable to the Owner shall govern.
- B. American Society for Testing and Materials (ASTM):
1. ASTM D1556, Density of Soil In Place by the Sand-Cone Method.
 2. ASTM D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³)).
 3. ASTM D6938, Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
 4. ASTM D422, Particle Size Analysis of Soils.
- C. Commonwealth of Massachusetts:

1. Massachusetts Highway Department Standard Specifications for Highways and Bridges.
 2. The Commonwealth of Massachusetts State Building Code 780 CMR, Ninth Edition (MSBC 9th Edition)
- D. American Association of State Highway and Transportation Officials (AASHTO):
1. AASHTO T-11, Standard Method of Test for Amount of Material Finer than 0.075 mm sieve in aggregate.
 2. AASHTO T-27, Standard Method of test for sieve analysis of fine and coarse aggregates.
- E. Occupational Safety and Health Act of 1970 (Public Law 91-596 of the United States, 29 USC Section 651 et seq.).

1.19 SUBMITTALS

- A. Product Data: For the following:
1. Each type of plastic warning tape.
 2. Geotextile – The contractor shall submit a 12" by 12" sample of geotextiles.
 3. Controlled low-strength material, including design mixture.
- B. Submit a detailed construction sequence plan for project excavation indicating temporary stockpile areas, side slopes of excavations, limits of required temporary excavation support and sequence and procedures for subgrade protection, excavation, concrete placement, moisture conditioning of on-site excavated soils used as fill, filling, backfill, and compaction.
- C. The Contractor shall submit, the name of imported material suppliers. Change of source suppliers shall require approval from the Architect.
- D. Grain-size distribution analysis test data shall be delivered with the samples. The analysis shall be performed in accordance with ASTM D 422 and shall at the minimum include the sieve sizes listed for the respective material in Part 2. The data shall include a plot of the gradation and the envelope of the specified material. A material shall be considered meeting the specifications when its gradation curve fits entirely within the specified envelope. Borrow soil materials with grain-size distribution curves that do not fall entirely within the specified envelope shall be deemed unacceptable.
- E. The Contractor shall submit to the Architect, manufacturer's literature and data on proposed compaction equipment.
- F. The Contractor shall provide to the Architect, on a daily basis, copies of field records documenting the location of stockpiled material, and stockpile identification data.
- G. The Contractor shall submit a scale plan daily that defines the location, limits, and depths of the area excavated.
- H. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:
1. Classification according to ASTM D 2487 of each onsite and borrow soil material proposed for fill and backfill.

2. Recent (less than one month old) Gradation Curve (ASTM-D422) and Laboratory compaction curve according to ASTM D 1557 for each on-site and borrow soil material proposed for fill and backfill.
- I. Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earthwork operations. Submit before earthwork begins.
- J. Excavation and Excavation Support Plan: Submit at least 10 calendar days prior to the start of the work a detailed plan for the sequence of excavation, and methods to be used for excavation support and dewatering of excavations. Submit engineering calculation stamped by a Massachusetts Registered Professional Engineer and shop drawings for earth support systems to be used.
- K. Dewatering plan shall be submitted at least 10 days before the start of construction. Dewatering and groundwater control systems shall be designed to keep excavations free of water and to avoid disturbance of the subgrade in accordance with Section 1.13 of these Specifications. The dewatering submittal shall include a plan clearly showing locations, depth, and size of deep stationary sump pumps.
- L. Rock blasting plan shall be submitted at least 10 days before the start of blasting operations. This submittal shall include description of blasting operations, handling procedure and storage of explosives, blasting limits and depths, blasting sequence, measures to limit vibrations, as needed, and measures to limit overblast and rock heave to less than 2 feet. The blasting plan shall include the report types of explosive and sizes of charge to be used in each area of rock removal, types of blasting mats, sequence of blasting operations, and procedures that will prevent damage to site improvements and structures on Project site and adjacent properties. The blasting plan shall also include measures to maintain recommended slopes of rock faces and to reduce overblast. Blasting shall not start until the blasting submittal is approved. Blast operations shall not commence until all reports and plans are received and approved by the Owner and the Architect.
- M. Prepare a preblast survey of all adjacent properties, properties and structures within 250 feet of nearest earth moving operations, including a structural inspection of the buildings and properties and shall include a written and photographic record of existing conditions.

1.20 SAMPLING AND TESTING

- A. The contractor shall submit two (2) 50-lbs samples of each type of fill material, in air-tight containers, proposed for use on-site in accordance with PART 2 - PRODUCTS, to the Owner's Geotechnical Engineer (Geotechnical Consultant) for preliminary compliance testing at least two (2) weeks prior to use. No fill material shall be delivered to the site or placed until the material has been preliminarily approved. The final review of the material will be based on a sample tested by the owner's testing agency upon delivery of the material to the site. The gradation curves shall fit entirely within the envelopes defined by the limits specified herein for the material to be approved for use at the site.
 1. Samples shall be delivered to the office of the Architect or as directed.
 2. Samples required in connection with compaction tests will be taken and transported by the Soils Representative.
 3. Additional tests, including grain-size analyses and laboratory compaction tests shall be performed on the material after it is delivered to the site.
 4. For on-site materials, submit representative samples, collected from each stockpile of excavated on-site material to be used, directly to the Owner's Geotechnical Consultant's office or as directed at least two (2) weeks in advance of use of these materials.

- B. Product Data: Submit location of pits for borrow material. Samples shall include name of source, name of material, sampling date, and intended use.
- C. Samples shall be representative of the source pit. If materials are found to vary once construction begins, the Contractor will be required to submit additional representative samples, for compliance testing, at his own cost.
- D. Compaction tests:
 - 1. Compaction tests shall be performed at all bench and other site fixture pads.
 - 2. Compaction tests shall be performed on each lift of placed and compacted material. Accordingly, it is the responsibility of the Contractor to provide ample notice to the testing agency to provide a field representative to perform field density tests.
- E. Materials imported to the site by the Contractor for on-site use shall not contain oil, hazardous waste, or deleterious materials.
 - 1. The Contractor shall be responsible for all costs incurred by the Owner as a result of the Contractor's action to import materials containing concentrations of oil and/or hazardous materials to the site, including the cost of removing the contaminated soil, the cost of remediation of onsite soils affected by the contamination, and the cost of replacement.
 - 2. In the event that site characterization of off-site borrow sources indicates that soils are acceptable to the Architect or Engineer for use, then chemical testing will not be required. It is anticipated that chemical testing would not normally be required for material from customarily utilized commercial borrow sources.

Fill material from "urban areas" with chemical testing indicating no exceedances of "Reportable Concentrations" may be used onsite if approved by the Owner.

If requested by the Owner or Engineer, based on review of the borrow site characterization, the Contractor shall conduct testing on proposed fill material and submit results prior to delivery to the site, at no additional cost to the Owner. Testing shall be conducted by a DEP-certified testing laboratory and shall include, at a minimum, the following analytical test data.

 - a. Total Petroleum Hydrocarbons (EPA Method 418.1) every 100 yards
 - b. Volatile Organic Compounds (EPA Method 8420) every 500 yards
 - c. PCB and Pesticides (EPA Method 8080) every 500 yards
 - d. Total RCRA Metals (EPA Method 6000-7000 series) every 500 yards
 - e. Polynuclear Aromatic Hydrocarbons (EPA Method 8270) every 500 yards
 - f. TCLP for those total parameters which exceed twenty times the TCP criteria every 500 yards.
 - g. Total cyanide (EPA 9020)
 - 3. All off-site material submitted for use on the project site shall conform to the S-1 Soils Standards contained in the Massachusetts Contingency Plan, dated October 1, 1993, Section 310 CMR 40.0975 or site soil background levels, whichever is lower. Samples will be chemically tested to determine their conformance with the S-1 Soils Standards and site soil background levels.
 - 4. Testing parameters and testing frequencies may be reduced, as directed by the Soils Representative.
 - 5. All sieve analyses for conformance of on-site and off-site fill materials to be used in the work shall be done by means of a mechanical wet sieve analysis and in accordance with ASTM D 422.

1.21 QUALITY ASSURANCE

- A. The Owner may retain and pay for the services of an independent testing agency (Soils Representative) to monitor and observe the backfill operations, perform laboratory tests on soil samples, and to perform field density tests; and a Geotechnical Engineer to periodically observe the earthwork operations, observe the preparation of the subgrade for footings, slabs, and if requested by the Owner paved areas, and to review laboratory and field test data. The geotechnical engineer may from time to time request that the contractor excavate tests pits, as required in item 1.2-B.9, ahead of excavation to confirm subsurface conditions.
- B. The Geotechnical Engineer's duties do not include the supervision or direction of the actual work by the Contractor, his employees or agents. Neither the presence of the Geotechnical Engineer nor any observation and testing by the Engineer shall excuse the contractor from defects discovered in his Work at that time or subsequent to the testing.
- C. The services of the Soils representative may include but are not limited to monitoring and performing observations of the backfill operations and testing during placement of fills and backfills within the proposed building, parking area, underneath structures in general, and controlled fill areas.
- D. Neither the presence of the Soils Representative and/or the Geotechnical Engineer, nor any observations and testing performed by them, nor failure to give notice of defects shall excuse the Contractor from defects discovered in his work.
- E. Subgrades of footings and slabs, and if requested by the Owner subgrades of paved areas, shall be observed by the geotechnical engineer before placing fill. The compaction and material composition shall be approved by the geotechnical engineer before placement. If inspections indicate subgrade does not meet specified requirements, the unsuitable subgrade shall be excavated, the unsuitable material shall be removed, and replaced with approved backfill material and compacted at no additional cost to the owner or architect. The work shall be done in accordance with this specification.

1. Testing frequency shall be as follows:

Material	Responsible Party	Situation	Test	Minimum Frequency
Structural Fill/	Contractor	Source Investi-	Grain Size	1 per source
Ordinary Fill/		gation	Moisture Density Relationship	1 per source
Processed	Owner	During	Grain Size t	1 per source
Gravel for Sub-		Placement	Moisture Density Relationship	1 per 100 tons
base/				
Common Bor-	Owner	As-Placed	Dry Density and As-Placed Moisture	2 per lift per location or
row/ Bedding				activity and no less than
Material/				1 every 500 sf
Crushed Stone /				
Pea Gravel				
Loam Borrow	Contractor	During Place-	PH, Nitrogen, Phosphorous, Potas-	2 per Acre
		ment	sium, and USDA Classification	
Riprap	Contractor	Source Investi-	Source Material Certification	1 per source
		gation	Specific Gravity	1 per source
	Contractor	During Place-	Source Material Certification	1 per 500 tons
		ment	Specific Gravity	1 per 500 tons

- a. The Owner reserves the right to modify the services of the Soils Representative or Geotechnical engineer.
- E. The contractor shall make provisions for allowing safe and timely observations and testing of Contractor's Work by the Geotechnical Engineer and by the Soils Representative.
- F. Pre-excavation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination."
 - 1. Before commencing earthwork, meet with representatives of the governing authorities, Owner, Architect, Engineer, consultants, Soils Representative, and other concerned entities. Review earthwork procedures and responsibilities including testing and inspection procedures and requirements. Notify participants at least 3 working days prior to convening conference. Record discussions and agreements and furnish a copy to each participant.
- G. Testing: Compaction tests will be required by the Owner and will be paid for by the Owner. No specific testing schedule has been established at this time. If tests indicate that density requirement have not been achieved, the contractor shall continue compacting the tested material. All retesting in these areas shall be paid for by the contractor.
- H. The Owner's Testing Agency will perform water content, gradation tests on onsite and processed materials, and compaction tests at a frequency and at locations as required. The results of these tests will be submitted to the Architect, and a copy submitted to the Contractor, on a timely basis so that the Contractor can take such action as is required to remedy the indicated deficiencies.

Contractor shall notify Architect when excavations have reached required subgrade and provide a minimum notice of 24 hours prior to placement of backfill on exposed subgrade. Density and Compaction Testing: The contractor is responsible to schedule compaction tests and allow adequate time for the proper execution of said tests. This section also applies to instances when the General Contractor resumes earthwork operations after a period of pause in earthwork operations that require observations by the Geotechnical Engineer.

1.22 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by the owner or others unless permitted in writing by Architect and then only after arranging to provide temporary utility services according to requirements indicated.
 - 1. Notify Architect not less than two days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Architect's written permission.
 - 3. Contact a utility-locator service for the area where Project is located before excavating.
- B. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies and Town of Wakefield to shut off services if lines are active.
- C. Subsurface investigations indicated the presence of fill material which contains organic matter. This material has limited reuse applications at the site.
- D. Subsurface investigations indicated the presence of sand and gravel materials which will likely be easily disturbed due to construction activities. This material is also likely to require regular moisture conditioning to obtain required compaction requirements.

1.23 MEASUREMENT

A. Measurement of Unsuitable Soil overexcavation:

1. Strip vegetation, topsoil, buried organic material and fill to a minimum depth of 1 foot below the existing grades in accordance with the Contract Documents or in accordance with drawings. Remove existing asphalt, curbing, cobbles, boulders, concrete, metal, woods, and above and below ground structures.
2. Remove unsuitable soils to top of natural soil as shown on the Contract Documents or as directed in the field by the Owner's Geotechnical Consultant in accordance with the Section 3.1-B, 3.3, 3.6, 3.7, 3.9, and 3.10 of these Specifications.
3. Remove rock to the lines and grades specified herein or those shown in the drawings, whichever is deeper.
4. Employ a Registered Land Surveyor to survey to bottom of the excavation for unsuitable soils throughout the building footprint. Excavations shall be surveyed at the corners, high and low points, and a maximum spacing for survey points of 20 feet in each direction on a grid.
5. Quantities shall be measured in their original position to the limits of clearly defined vertical construction lines and to the depth required for the defined construction. Payment will be at the Contract Unit Rates.
6. All quantities are measures in place. No swell or fluff factor shall be allowed in estimating quantities.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Segregate excavated material based upon material type to enable reuse in appropriate locations based upon material type as described in Section 3.5.
- B. Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

2.2 SOIL MATERIALS

- A. Use of materials shall be as described below and as shown in the Drawings.
- B. Fill material will not be accepted from off-site borrow sources that are Massachusetts DEP MCP disposal sites. Common borrow material obtained from off-site borrow sources that have no known releases or disposal of oil and/or hazardous material shall be acceptable for use only when accompanied by documentation stating there has been no known releases or disposal of oil and/or hazardous materials at the off-site borrow site.
- C. Fill material shall be free from frost/ice and snow, rocks with a diameter greater than 2/3 of the loose lift thickness as specified herein, and foreign matter, such as construction debris, asphalt, trash, wood, roots, leaves, sod, and organic matter. All fill material shall be maintained by the contractor at suitable moisture contents for proper placement and compaction as specified herein

- D. Offsite pulverized pavement and crushed concrete are not acceptable for fill material except as specified herein.

2.3 STRUCTURAL FILL

- A. Structural Fill shall have a plasticity index of less than 6 and shall meet the gradation requirements shown below. Structural Fill shall be compacted in maximum 9-inch loose lifts to at least 95 percent of the Modified Proctor maximum dry density (ASTM D1557), with moisture contents within ± 2 percentage points of optimum moisture content.

Sieve Size	Percent Passing by Weight
3 inches	100
1 ½ inch	80 – 100
½ inch	50 – 100
No. 4	30 – 85
No. 20	15 – 60
No. 60	5 – 35
No. 200*	0 - 10

*0 – 5 In top 12 inches under sidewalks, walkways, rubber surface in play areas, equipment pads, and unheated and exterior slabs (Select Fill).

Use structural fill within building areas beneath floor footings and slabs, retaining wall foundations, and in other soil-bearing situations.

Crushed concrete can be used as Structural Fill provided it meet the requirements of these specifications. If used, the crushed concrete shall be used up to 6 inches below the bottom of footings and 12 inches below the bottom of slabs. Crushed concrete shall be free of debris, wood, and organic material, and shall meet the environmental requirements set forth in these specifications.

Use Structural Fill with less than 5 percent fines in top 12 inches under exterior slabs-on-grade including under sidewalks, walkways, rubber surface in play areas, equipment pads, and unheated and exterior slabs.

2.4 ORDINARY FILL

- A. Ordinary Fill shall have a plasticity index of less than 6 and shall meet the gradation requirements shown below. Ordinary Fill shall be compacted in maximum 9-inch loose lifts to at least 95 percent of the Modified Proctor maximum dry density (ASTM D1557), with moisture content s within ± 2 percentage points of optimum moisture content.

Sieve Size	Percent Passing by Weight
6 inches	100
1 inch	50 – 100
No. 4	20 - 100
No. 20	10 - 70
No. 60	5 – 45
No. 200	0 - 20

Use Ordinary Fill for general grading; as backfill for embankments, behind the free draining backfill behind retaining walls, beneath the base layer of landscape areas; and beneath the subbase layer in paved areas outside the building footprint.

Crushed concrete can be used as Ordinary Fill provided it meet the requirements set forth by this specification.

2.5 COMMON BORROW

- C. Common Borrow material shall be soil containing no stone larger than 8 inches and shall be substantially free of organic loam, wood, trash, or other objectionable materials which may be decomposable, compressible or which cannot be properly compacted. Onsite and offsite Common Borrow materials shall not contain more than 30 and 20% percent by weight of silt and clay, respectively.
 - 1. No Common Borrow shall be imported until available onsite Ordinary Fill has been utilized or with prior written approval from the Architect.
 - 2. Common Borrow material from off-site borrow sources shall contain no detectable concentrations of asbestos.
 - 3. Crushed concrete can be used as Common Borrow provided it meet the requirements of these specifications.
 - 4. Common Borrow can be used beneath the topsoil in landscaped areas, and at depths greater than 3 feet in paved areas.

2.6 PROCESSED GRAVEL FOR SUBBASE

- A. Processed Gravel for Subbase shall be onsite or imported material conforming to Item M1.03.1 of the State Standards. This material can be used as subbase in the top 12 inches beneath paved areas.
- B. Processed Gravel for Subbase may be anticipated to be onsite in limited quantities.
- C. Crushed concrete shall not be used as Processed Gravel for Subbase.

2.7 BEDDING MATERIAL

- A. Crushed Stone Bedding Material shall be imported material conforming to Item M2.01.3 of the State Standards.
- B. Coarse Sand Bedding Material shall be imported material conforming to Item M1.04.0 type A of the State Standards.

2.8 SAND FILL

- A. Sand Fill: To be used as utility bedding and backfill. It shall be hard, durable sand free from ice, snow, roots, sod and other deleterious matter conforming to the material and gradation requirements for Type B Sand Borrow, MassDOT Item M1.04.0. The Sand Fill shall be used as backfilling material around banks of pipes. The Sand Fill shall be graded within the following limits:

<u>Sieve Size</u>	<u>% Passing by Weight</u>
3/8-inch	100
No.200	0-10

2.9 DENSE GRADED CRUSHED STONE FOR SUBBASE

- A. Dense graded Crushed Stone for subbase shall be imported material conforming to Item M2.01.7 of the State Standards. This material shall be used as an alternate to Processed Gravel for Subbase in the top 12 inches immediately beneath paved areas.
- B. Crushed concrete shall not be used as Dense Graded Crushed Stone for Subbase.
- C. Dense graded Crushed Stone for subbase are generally not anticipated to be present onsite. Material present under existing paved areas should be stockpiled and tested for compliance before reusing.

2.10 CRUSHED STONE

- A. Crushed Stone shall be impacted durable material with maximum of 1 ½ " or 2" as specified in the Drawings. Stone used for drainage components shall be double washed. For all other applications fines shall be <1% unless otherwise noted. Crushed stone shall meet the following gradation:

Size (inches)	Percent Finer
1 ½" – 2"	100%
1 ¼"	85% - 100%
¾"	10% - 40%
½"	0% - 8%
#200	< 1%

- B. ¾" Crushed Stone shall comply with State Standards M2.01.4.
- C. 1/4" to 3/8" Crushed Stone shall comply with State Standards M2.01.6.
- D. Crushed stone for stormwater detention systems and infiltration systems shall be double-washed.

2.11 PEA GRAVEL

- A. Clean naturally rounded aggregate with particle sizes no larger than 3/4 of an inch with no more than 5% passing the #8 sieve. The dry density shall be a minimum of 95 pounds per cubic foot.

2.12 WASHED STONE

- A. Washed stone shall be free from shale, clay, organic materials, and debris with stone sizes conforming to No. 4 stone as specified by ASTM D448. Not more than 0.5 percent of satisfactory material passing a No. 200 sieve shall be allowed to adhere to the stone. Laboratory testing shall be completed in compliance with ASTM D6913, and results shall be submitted to the Civil Engineer for approval.

2.13 FILTER FABRIC

- A. Filter fabric shall be nonwoven, needle-punched geotextile, manufactured for subsurface drainage applications, made from polypropylene fibers with elongation greater than 50 percent and complying with AASHTO M288. Filter fabric shall consist of Mirafi 140N, US120NW, GeoTex 401, or approved equal.
- B. High Visibility Filter Fabric shall consist of US 160NW-HVO non-woven orange filter fabric, GeoTex 601OR, or Mirafi 160N/O, or approved equal.

2.14 GEOTEXTILE FABRIC

- A. Geotextile No. 1: Geotextile Fabric for erosion control/slope protection/separation/filtration shall conform to Item M9.50.0 type IV of the State Standards. Geotextile No. 1 is a nonwoven geotextile composed of polypropylene fibers, which are formed into a stable network such that fibers retain their

relative position. The product is inert to biological degradation and resists naturally encountered chemicals, alkalis, and acids.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
Grab Tensile Strength	ASTM D 4632-91	lbs	120
Grab Tensile Elongation	ASTM D 4632-91	%	50
Trapezoid Tear Strength	ASTM D 4533-91	lbs	50
Mullen Burst Strength	ASTM D 3786-87	psi	225
Puncture Strength	ASTM D 4833-00	lbs	65
Apparent Opening Size (AOS)	ASTM D 4751-99A	U.S. Sieve	70
Permittivity	ASTM D 4491-99A	sec ⁻¹	1.8
Permeability	ASTM D 4491-99A	sec	0.21
Flow Rate	ASTM D 4491-99A	gal/min/ft	135
UV Resistance (at 500 hours)	ASTM D 4355-02	% strength retained	70
Physical Properties	Test Method	Unit	Typical Value
Weight	ASTM D 5261-92	oz/yd	4.8
Thickness	ASTM D 5199-01	mils	55
Roll Dimensions (width x length)	--	ft	12.5 x 360 / 15 x 360
Roll Area	--	yd	500 / 600
Estimated Roll Weight	--	lb	164 / 197

- B. Geotextile No. 2: Geotextile No. 2 is a nonwoven geotextile composed of polypropylene fibers, which are formed into a stable network such that fibers retain their relative position. The product is inert to biological degradation and resists naturally encountered chemicals, alkalis, and acids. Geotextile No. 2 shall be used where the project Civil Engineer required it.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value
Grab Tensile Strength	ASTM D 4632	lbs	160
Grab Tensile Elongation	ASTM D 4632	%	50
Trapezoid Tear Strength	ASTM D 4533	lbs	60

Mullen Burst Strength	ASTM D 3786	psi	305
Puncture Strength	ASTM D 4833	lbs	95
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Sieve	70
Permittivity	ASTM D 4491	sec ⁻¹	1.4
Permeability	ASTM D 4491	sec	0.22
Flow Rate	ASTM D 4491	gal/min/ft	110
UV Resistance (at 500 hours)	ASTM D 4355	% strength retained	70

Physical Properties	Test Method	Unit	Typical Value
Weight	ASTM D 5261	oz/yd	6.4
Thickness	ASTM D 5199	mils	75
Roll Dimensions (width x length)	--	ft	15 x 300
Roll Area	--	yd	500
Estimated Roll Weight	--	lb	217

C. Geotextile No. 3: Geotextile for the installation of underground tank

1. Woven geotextile fabric with a minimum grab tensile strength of 120 lbs/inch and a maximum apparent opening size of #50 US sieve (0.300 mm)
- D. A geotextile fabric shall not be used between crushed stone and soil fill material at the base of retaining walls. Where separation between crushed stone and soil fill material is required, the crushed stone shall be choked by means of a soil filter.
- E. A geotextile fabric shall be used to separate crushed stone used as a drain within or behind MSE and modular retaining walls and the backfill/natural soil.

2.15 DRAINAGE BASE AND AGGREGATE

- A. Drainage stone for bottom and top layers indicated on the contract drawings shall be in accordance with the following and confirmed in writing by the synthetic turf manufacturer to meet their engineered recommendations. Specific recommendations for the size and gradation of the stone shall be based upon the thickness and slopes indicated on the detail. The drainage stone shall be minimally handled in a manner which prevents segregation or breakdown of the material and contamination from soils and other materials.

Synthetic Turf Base Materials

1. Bottom Drainage Layer at Synthetic Turf: The material shall consist of clean, hard, crushed aggregate that is angular and durable derived from a stone quarry free of all deleterious materials. Gradation of sample provided for testing and approval shall be within the following range:

U.S. Sieve No.	Percent Finer by Weight
2"	100
1-1/2"	90-100
1"	75-100
3/4"	65-95
1/2"	55-85
3/8"	40-75
1/4"	25-65
No. 4	15-60
No. 8	0-40
No. 16	0-20
No. 30	0-7
No.50/60	0-5
No.100	0-3
No.200	0-2

2. Top Drainage Layer at Synthetic Turf: The material shall consist of clean, hard, crushed aggregate that is angular and durable derived from a stone quarry free of all deleterious materials. Gradation of sample provided for testing and approval shall be within the following range:

U.S. Sieve No.	Percent Finer by Weight
1/2"	100
3/8"	85-100
1/4"	75-100
No. 4	60-90
No. 8	35-75
No. 16	10-55
No. 30	0-40
No.50/60	0-15
No.100	0-8
No.200	0-2

3. Criteria for Bottom and Top Drainage Layer materials:

a. To ensure structural stability: $\frac{D_{60}}{D_{10}} > 5$ and $1 < \frac{D_{30}^2}{D_{10} D_{60}} < 3$

Fragmentation must be 100%.

b. To ensure separation of both layers: $\frac{D_{85} \text{ of top layer}}{D_{15} \text{ of base layer}} > 2$

and $3 < \frac{D_{50} \text{ of base layer}}{D_{50} \text{ of top layer}} < 6$

- c. To ensure proper drainage:

Permeability of bottom layer $> 50 \text{ in/hr}$ ($3.5 \times 10^{-2} \text{ cm/sec}$)

Permeability of top layer > 20 in/hr (2.0×10^{-2} cm/sec)
Porosity of both stones > 25%
(When stone is saturated and compacted to 95% Proctor)

Laboratory test: ASTM D 2434 Permeability of Granular Soils (Constant Head)
Field test: ASTM D 3855, Method for Infiltration Rate of Soils Using Double-Ring Infiltrometer

- d. Depending on the type of rock present in the crushed stone mix, other mechanical characteristics might be necessary for approval
- e. "D_x" is the size of the sieve (in mm) that lets pass x% of the stone. For example, D₆₀ is the size of the sieve that lets 60% of the stone pass. These sizes, for calculation purposes, may be obtained by interpolation on a semi-log graph of the sieve analysis.
- f. Soft aggregate materials such as sedimentary rock sources are not acceptable. Questionable materials shall be evaluated using a sulfate soundness test (ASTM C-88) and LA Abrasion Test (ASTM C-131) and shall be within the following criteria:

Test Method	Criteria
Sulfate Soundness (ASTM C-88)	Not to exceed 10% loss
LA Abrasion (ASTM C-131)	Not to exceed 20% loss

2.16 OTHER SOIL MATERIAL

- A. Drainage Aggregate: Narrowly graded mixture of washed crushed stone or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch (37.5-mm) sieve and 0 to 5 percent passing a No. 8 (2.36-mm) sieve. Crushed blasted rock that meet the gradation requirements specified herein may be used as Drainage Aggregates.
- B. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural soil; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch (25-mm) sieve and 0 to 5 percent passing a No. 4 (4.75-mm) sieve. Crushed blasted rock that meets the gradation requirements specified herein may be used as Filter Material.
- C. Fine Aggregate: ASTM C 33; fine aggregate, natural, or manufactured sand.
- D. River Stone: River stone shall be 1 1/2" to 3" rounded and 3" to 6" rounded and oval, smooth stone, color range shall be warm tones of buff, beige, tan and gray. Color range shall be consistent throughout. Stone shall be clean and washed free of deleterious material. Contractor to submit 5-gallon container sample for each size range with source indicated.
- E. Rip-rap: rip-rap shall be sound, durable rock which is angular in shape in accordance with M2.02.0 of the State Specifications. Crushed blasted rock that meets the gradation requirements specified herein may be used as rip-rap.
- F. Refer to Landscape Sections for other materials.

2.17 ACCESSORIES

- A. Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility; colored as follows:
- B. Detectable Warning Tape: Acid- and alkali-resistant polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored as follows:
 - 1. Red: Electric.
 - 2. Yellow: Gas, oil, steam, and dangerous materials.
 - 3. Orange: Telephone and other communications.
 - 4. Blue: Water systems.
 - 5. Green: Sewer systems.

PART 3 – EXECUTION

3.1 GENERAL

- A. Prior to commencing work, the Contractor shall establish property line locations and place construction control markers clearly visible and understandable to workers in the field. The Contractor shall exercise due care so as not to disturb adjacent structures and shall leave the Site in clean and orderly condition upon completion of the work.
- B. Unanticipated Soil Conditions:
 - 1. Removal of unsuitable materials up to the depths shown in the drawings and/or specified herein shall be part of the base bid and shall not be considered an unanticipated soil condition. The depth to the bottom of unsuitable material shall be estimated by interpolating between the depths to unsuitable material in the nearest borings and/or test pit.
 - 2. If unsuitable bearing materials are encountered at the specified subgrade depths, i.e., deeper than the elevations shown in the Geotechnical Report, the Contractor shall notify the Architect. The Contractor shall carry excavation deeper and replace the excavated material with suitable/approved compacted fill or lean concrete as directed by the Architect or geotechnical engineer.
 - 3. Removal of such material and its replacement as directed by the Architect will be paid as extra compensation in quantity approved by the Architect and calculated using survey points of the excavated area. Only changes in the work authorized in advance by the Architect in writing shall constitute an adjustment in the Contract Price.
 - 4. Material that is above or below optimum moisture for compaction of the particular material in place as determined by the Architect or the Soils Representative and is disturbed by the Contractor during construction operations so that proper compaction cannot be reached shall not be considered as unsuitable bearing materials. This material shall be removed and replaced with lean concrete or with approved material as directed by the Architect or Geotechnical Engineer or Soils Representative at no additional cost to the Owner.
 - 5. The Contractor shall follow a construction procedure which permits clear visual identification of firm natural soil by the Geotechnical Engineer.
- C. Excessive Excavation: If any part of the general or trench excavation is carried, through error, beyond the depth and dimensions indicated on the Drawings or called for in the Specifications, the

Contractor at his own expense, shall furnish and install compacted gravel fill, concrete, or take other remedial measures as directed by the Architect to bring fill material up to the required level or dimension.

- D. The Contractor shall reuse onsite excavated soils that meet the gradation requirements of materials specified herein. Solid waste consisting of brick, concrete, asphalt, cobbles, boulders, excavated or blasted rock, and all unsuitable excavated materials shall become the property of the Contractor and be legally disposed of off-site at no additional cost to the Owner.

Samples and Testing:

1. Excavated material taken directly from onsite cuts that will meet the Specifications may be used as fill provided the Contractor obtains written approval from the Architect. No such fill material shall be placed until approved for use by the Architect in writing and until test results, including gradation and compaction tests are approved by the Geotechnical Engineer.
 2. Testing of materials as delivered in accordance with item 1.2-A. Remove rejected materials and replace with approved backfill material, whether in stockpiles or in place.
 3. The existing fill, subsoil, and the natural soil contain high fines contents. Such soils are very susceptible to disturbance when exposed to moisture. Care shall be exercised during construction to maintain a dry working subgrade. Provide working mats, e. g., crushed stone or concrete mud mats, to reduce the potential for disturbance of the foundation subgrade and to improve working conditions. The use of crushed stone to stabilize soft subgrade shall be at no additional cost to the Owner.
- E. Deficiency of Fill Material: Provide required additional fill material to complete the work if a sufficient quantity of suitable material is not available from the required excavation on the project site at no additional cost to the Owner.
- F. Surplus Fill Material: Surplus fill that is not required to fulfill the requirements of the Contract shall be removed from the site and legally disposed of at no additional cost to the Owner.
- G. Protect all benchmarks, monuments, and property boundary pins. Replace if destroyed by contractor's operation.

3.2 DRAINAGE STONE

- A. Bottom and top layers of drainage materials meeting the manufacturer's engineered criteria for this project, shall be placed and compacted in accordance with the manufacturer's installation requirements. A minimum of two (2) separate layers of drainage materials placement will be required.
- B. Drainage stone shall be placed as per requirements stated herein. The finished surface of the top drainage stone layer shall be fine graded in preparation of measurement. The contractor shall measure the top drainage stone layer elevations with a laser level at a minimum of 100 evenly spaced points throughout the field area to attain the required elevations. Surface tolerance shall not exceed 3/16 inch in ten feet. Written approval of the drainage base by the manufacturer's representative is required prior to installation of the synthetic turf system.

Area	ASTM Density Degree of Compaction

Synthetic Turf Drainage Layer	92% Min/ 95% Max
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C. Placing, Spreading and Compacting Base Stone Material at Synthetic Turf Field:

1. Fill materials are to be placed as designated herein and as indicated on the Contract Drawings.
 - a. Base Stone shall be placed as follows and compacted as specified herein: As a base course, over ¾-inch Crushed Stone, as shown on the Drawings.
 - b. Finishing Top Stone shall be placed as follows and compacted as specified herein: Finishing Stone shall be 1" compacted depth above Base Stone as shown on the Drawings.
2. The Contractor shall not place a layer of compacted fill on soil that was permitted to freeze prior to compaction or on snow or ice. Removal of these unsatisfactory materials will be required as directed by the Owner.
3. After each layer has been placed, it shall be thoroughly compacted to the specified density. Compaction shall be continuous over the entire area and the equipment shall make sufficient passes to ensure that the desired density is obtained. A minimum of four coverage's with acceptable compaction equipment is a requirement. These coverage's are to be provided as a systematic compactive effort; incidental coverage's due to construction vehicle traffic through the area will not be included.
4. Laser grading shall be used in the construction of the base construction for the Synthetic Turf fields.

3.3 PREPARATION

- A. The Contractor shall be deemed to have inspected the Site and satisfied himself/herself as to actual grades and levels and true conditions under which the Work will be performed.
- B. Areas required for execution of Work shall be cleared. The work area shall be free of standing water and shall be dry.
- C. All site health and safety controls shall be fully established and in operation prior to beginning any demolition, soil, and fill excavation. Site controls shall include but not be limited to work zones properly barricaded, wheel wash and decontamination facilities, and all support equipment and supplies including personal protective equipment. All site controls shall be reviewed by the Architect in the field.
- D. The Contractor shall provide all layout field data, including ties, to the Architect. The Contractor shall maintain all required field controls throughout the performance of the Work.
- E. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
- F. Preparation of subgrade for earthwork operations including removal of vegetation, topsoil, debris, cobbles, boulders, rock as necessary, obstructions, and deleterious materials from ground surface is specified in Section 31 10 00 "Site Clearing."
- G. Protect and maintain erosion and sedimentation controls, which are specified in Division 31 Section 31 25 00 – Erosion and Sedimentation Controls.

- H. Provide protective insulating materials to protect subgrades and foundation soils against freezing temperatures or frost.
- I. Provide excavation support, shoring or bracing as necessary to perform the excavations and to support the bank of the stream during the removal of the unsuitable materials.
- J. Provide groundwater Control, dewatering, pumping, bailing and control of all groundwater and surface water for all work under this contract.

3.4 SUBGRADE PREPARATION

- A. Topsoil, forest mat, subsoil, existing fill, buried organic soil, tree stumps, roots balls, cobbles, boulders, abandoned utilities, existing and abandoned foundations, asphalt, demolition debris, and other below-ground structures shall be entirely removed from within the footprints of the proposed buildings before the start of foundation work. The removal shall extend vertically to the top of the natural soil or to rock, and laterally beyond the limits of the influence zone of 5 feet beyond the limits of the proposed building, whichever is greater.
- B. The topsoil, forest mat, and surficial organic material, tree stumps, rootballs, asphalt, and concrete structures and other deleterious material shall be entirely removed from within the proposed driveways and parking lots (paved areas). Abandoned/buried foundations, if any, should be removed within the proposed paved areas and athletic fields at least 2 feet beneath the bottom of the subbase layer of the proposed paved areas, and 2 feet beneath the topsoil or the subbase of synthetic turf in athletic fields.
- C. Cobbles and boulders should be removed at least 6 inches from beneath footings, 24 inches beneath the bottom of slabs and paved areas, and 24 inches beneath the topsoil or the base material for the synthetic turf in athletic fields. The resulting excavations should be backfilled with compacted Structural Fill under the building, and with Ordinary Fill under the subbase of paved areas and under the base material in athletic fields.
- D. Tree stumps, root balls, and roots larger than ½ inch in diameter shall be removed and the cavities filled with approved backfill material and compacted in accordance with this Specification.
- E. After the subsoil, existing fill, surficial and buried organic material, and unsuitable material are removed from within the proposed buildings, the exposed subgrade in the natural soil shall be compacted using at least four passes of a vibratory roller compactor imparting a minimum dynamic effort of 40 kips.
- F. The base of the footing excavations in the natural soil shall be compacted with a dynamic vibratory compactor weighing at least 200 pounds and imparting a minimum of 4 kips of force to the subgrade, before placing the backfill or concrete.
- G. The base material of athletic fields should conform to the gradation and placement requirements of the landscape architect or the manufacturer/installer of synthetic turf.
- H. The grades within the proposed building shall be restored using Structural Fill up to the bottom of the proposed slabs or bottom of the under-slab drainage system when required, in accordance with drawings and details.

- I. Due to the susceptibility of the natural soil to disturbance under foot and vehicular traffic, a minimum of 12 inches of Structural Fill or 3/4-inch crushed stone shall be placed under the footings to provide a firm working surface during placement of formwork and rebar.
- J. To improve the existing fill under the proposed paved areas, the exposed subgrade in the existing fill material (i.e., after removing the surficial topsoil, organic material) shall be compacted with at least six (6) passes of a heavy vibratory roller compactor imparting a dynamic effort of at least 40 kips. Where soft zones of soil are observed, the soft soil shall be removed, and the grade shall be restored using Ordinary Fill to the bottom of the proposed subbase layer. Where buried organic material is present beneath the proposed paved areas, it shall be removed at least 1.5 feet beneath the bottom of the proposed subbase layer. The exposed surface shall be proofrolled before placing backfill.
- K. In paved areas, the subsoil shall be removed to the top of the natural sand, or to a minimum depth of 18 inches beneath the bottom of the proposed pavement, whichever occurs first. Where subsoil is encountered and extends to depths greater than 18 inches beneath the bottom of the proposed pavement, the subsoil deeper than 18 inches beneath the bottom of the proposed pavement may remain in place provided that it is improved as described in the item below.
- L. After the surficial topsoil and forest mat are entirely removed and after the subsoil is removed from within the proposed paved areas in accordance with the item above, the existing subsoil deeper than 18 inches beneath the bottom of the proposed pavement should be improved by compacting the exposed surface with at least eight (8) passes (4 passes in each direction) of a vibratory roller compactor imparting a dynamic effort of at least 40 kips. Where soft zones of soil are observed, the soft soil should be removed, and the grade should be restored using Ordinary Fill to the bottom of the proposed subbase layer. If pumping of the subsoil deeper than 18 inches beneath the bottom of the proposed grade is observed, the compactor should be switched to static mode and the soft material should be removed and replaced with Ordinary Fill.
- M. After the surficial organic topsoil is removed from within the proposed athletic fields, the existing fill, or natural soil shall be proofrolled with a loaded rubber tire truck or with a large vibratory roller compactor imparting a minimum dynamic effort of 40 kips. Where soft zones are indicated by the proofrolling, the soft zones should be removed and the grades should be restored using Ordinary Fill to the bottom of the base material of the proposed turf designed by the landscape architect or the manufacturer/installer of synthetic turf, if any.
- N. In areas requiring rock excavations, disturbed rock material or rock that has heaved as a result of blasting and has been removed in accordance with 3.3-N, it shall be replaced with Structural Fill or crushed stone within the footprint of the proposed building, and with Ordinary Fill beneath the pavement subbase of the proposed parking lots and driveways.
- O. The bottom of footings bearing in bedrock shall be prepared as level as possible and shall not be sloped steeper than 12H:1V.
- P. Rock surfaces that heave due to blasting shall be compacted with a vibratory roller compactor that imparts a minimum of 40 kips to the rock surface, prior to placing fill. Where the thickness of heaved rock is more than 2 feet, the heaved rock shall be removed and replaced with approved backfill material.
- Q. Granular fill shall not be placed directly on rock surfaces containing voids. Suitably sized crushed stone or a geotextile for separation shall be placed on the fractured surface prior to placing the fill to limit migration of smaller particles into the voids.

- R. Under utility pipes, manholes, and catch basins, rock shall be cut a minimum of 12 inches beneath the pipe or structure.
- S. Rock excavation and rock blasting shall be performed in accordance with Sections 3.3 and 3.7 of these Specifications and the Geotechnical Report.
- T. Laterally, the rock shall be removed at least 1 foot beyond the limits of footings and 3 feet beyond the limits of walls, and 5 feet beyond the limits of buildings. Rock shall be cut a minimum of 12 inches outside utility structures and a minimum of 18 inches on each side of utility pipes.
- U. Contractor shall excavate from within the Building Area/Zone of Influence all unsuitable soils to a depth sufficient to reach the native soils as specified herein, within the geotechnical report, and within the contract plans.
- V. All excavated materials shall be segregated such that reusable material meeting the gradations provided for above are separated from organics and all other deleterious material.
- W. Once the final subgrade has been reached, and upon acceptance by the Architect and Soils Representative, Contractor shall backfill the excavated area with Structural Fill in the influence zone of building areas and Ordinary Fill in paved areas. Limits of excavation shall be determined in the field based upon observed conditions.

3.5 PROOF COMPACTING

- A. Areas requiring excavation shall be excavated to subgrade and then proof compacted as specified in Section 1.2 of this Specification Section.
- B. Where soft zones are revealed by compaction efforts and where organic soil is exposed, the soft material or organic soil shall be removed and replaced with Structural Fill in the influence zone of building areas and utility trenches and Ordinary Fill in paved areas.

3.6 REUSE OF ONSITE MATERIALS AND PROCESSING OF ONSITE MATERIALS

- A. Based on the borings the existing fill contains up to 25 percent fines, the subsoil contains up to 45 percent fines, the buried organic soil layer contains up to 30 percent fines, and the natural soil layer contains up to 50 percent fines. Subgrade support capacities may deteriorate when such soils become wet and/or disturbed. The contractor shall keep exposed subgrades properly drained and free of ponded water. Subgrades shall be protected from machine and foot traffic to reduce disturbance. Placed onsite material that become soft and unsuitable to support additional lifts of fill shall be removed and replaced at no additional cost to the owner. The contractor shall not make claims due to difficulty handling the onsite material.
- B. Organic soils cannot be reused for backfill except as directed by the landscape architect.
- C. The contractor shall plan on disposing of the excavated existing fill that does not meet the gradation requirements set forth by this specification and importing offsite materials for backfill, except for fill placed in paved and landscape areas at depths greater than 3 feet beneath the bottom of the subbase layer of pavement. Excavated material free of organic matter, meeting the gradation requirement for Common Borrow, and approved for reuse by the environmental professional can be placed in paved areas at depths greater than 3 feet from the bottom of the subbase layer of paved areas provided that the maximum particle size is less than 2/3 of the lift thickness, the fines content is less than 30 percent, the material is compacted to a minimum relative compaction of 95 percent. This backfill material shall be replaced at contractor's cost if it becomes soft as a result of exposure to wetness.

- D. Should onsite materials be encountered that are suitable for reuse in accordance with the requirements for these specifications, the Owner shall receive a credit from the contractor for the quantity of reused onsite material. The credit shall be based on the difference in unit rates between imported and onsite material (including the cost of stockpiling, and processing, if applicable) for the particular soil designation. The contractor shall provide Unit Rates for these materials in his base bid.
- E. Solid waste consisting of brick, concrete, asphalt, cobbles, and boulders that measure less than 3 cubic yards in volume shall become the property of the Contractor and be legally disposed of off-site at no additional cost to the Owner.
- F. Excavated onsite soils which are suitable for re-use at the time of excavation but become frozen or too wet for re-use due to poor material handling practices shall be disposed of off-site and replaced as necessary at no additional cost to the Owner.
- G. The processing of the existing building concrete and brick materials into Ordinary Fill shall be allowed after remediation in accordance with hazardous report.
- H. The Contractor must amend the existing stockpiles if testing determines that the stockpiles do not meet the specifications for their intended use. The Contractor shall provide third party sampling and testing for all soils amended on-site.
- I. The Contractor shall be allowed to mobilize a rock crusher to the site to process cobbles, boulders, blasted rock, and imported rock by blending these materials with the existing fill and natural soil and crushing them to produce well graded materials, provided that these materials are maintained at suitable moisture contents for proper compaction processed material obtained by crushing blasted rock, boulders, and soil shall meet the gradation requirements of Ordinary Fill and Structural Fill. Material produced by the crushing operation shall be well graded so as to reduce the potential for formation of honeycombs during its placement and compaction.
- J. The contractor shall protect stockpiled processed and unprocessed materials from exposure to moisture using tarps. The tarps shall be secured so as not to be moved by wind or other action. No claim shall be made, by the contractor, due to failure to comply with this requirement.
- K. When processing the blasted rock, the Contractor shall mix the blasted rock with onsite soil free of organic soil to produce a well graded processed material meeting the specification of the material for which it is intended for use.
- L. Before blasted rock, cobbles, and boulders that are crushed and processed onsite is reused, they shall be observed and approved by the geotechnical engineer. At the start of the crushing operations, the soil to rock proportions placed into the crusher shall be varied until the processed material meets the appropriate gradation requirements. The soil to rock proportion thus achieved shall be maintained throughout the duration of the project.
- M. The material placed into the crusher shall be free of organics, wood, and other deleterious matter.
- N. The jaws of the crusher shall be adjusted periodically to maintain the crushing gradation.
- O. Excess blasted rock, processed or unprocessed, not used on site shall be the property of the Contractor and shall be removed offsite at no additional cost to the Owner.

3.6 EXCAVATION, GENERAL

- A. The Contractor shall remain responsible for adequacy and safety of construction means, methods and techniques.
- B. The Contractor shall complete all excavations regardless of the type, nature or condition of the material encountered. The Contractor shall be solely responsible for making all excavations in a safe manner.
- C. The Architect shall be notified of unexpected subsurface conditions. Work shall be discontinued in affected areas until notified in writing to resume work by the Architect. No claim shall be made, by the contractor, due to failure to comply with this requirement.
- D. Displaced or loose soil or rock shall be prevented from falling into any excavation. The stability of soil and rock slopes shall be maintained in accordance with applicable local, state, and federal regulations and guidelines.
- E. All loose material shall be removed from the bottom of the excavation so that the bottom shall be in an undisturbed condition. If removal of the loose material results in excavation beyond the work limits and over excavation has not been approved by the Architect; the restoration of the excavation to grade shall be done at no additional cost to the Owner.
- F. When the bottom of the excavation shall, by error of the Contractor, have been taken to a depth greater than the depth specified, said condition shall be corrected by refilling to the proper grade with approved backfill material or the design shall be altered in a fashion acceptable to the Architect to compensate for said error. All measures taken to rectify conditions caused by over excavation shall have the Architect's approval, and any increase in cost resulting from such measures shall be borne by the Contractor.
- G. Excavation shall not be performed when weather conditions or the conditions of the materials are such that, in the opinion of the Architect, work cannot be performed satisfactorily.
- H. Appropriate measures shall be provided to retain excavation sidewalls and to ensure that persons working in or near the excavation are protected. Sheet piling or bracing may be used to support the walls of excavations and to protect against rockfalls in excavated rock faces. Method, design, construction and adequacy of any required bracing shall meet the OSHA requirements of 29 CFR Part 1926 and are the responsibility of the Contractor.
All damage to structures, utilities, landscape and hardscape features, related to or caused by the excavation shall be repaired at the expense of the Contractor.
- I. Classification:
 - 1. Unclassified Excavation - For the purposes of payment, excavations described in Section 3.3 and backfill with suitable materials as specified herein shall be unclassified, i.e., shall be included in the base bid and shall not be paid for using Unit Prices. Excavation shall comprise and include the satisfactory excavation, removal, and disposal of all materials encountered within the lines and grades shown in the Drawings or limits specified herein, whichever is deeper, regardless of the nature of the materials, and shall be understood to include, but not be limited to, bedrock, earth, topsoil, subsoil, hardpan, fill, foundations, pavements, curbs, piping, railroad track and ties, cobblestones, footings, bricks, concrete, abandoned drainage and utility structures, debris, and materials classified as unsuitable materials. All excavation and replacement, if applicable, with suitable material within the lines and grades shown in the Drawings or the limits specified herein, whichever is deeper, will be

considered and bid as unclassified and shall be included in the Contractor's lump sum (i.e., shall not be paid for using Unit Rates).

2. All excavation and replacement, if applicable, with suitable material within the lines and grades shown in Section 3.3 or in the Drawings, whichever is deeper, shall be considered and bid as unclassified and shall be included in the Contractor's lump sum (i.e., shall not be paid for using Contract Unit Rates).
 3. The removal of topsoil, existing fill, subsoil, rock, cobbles, and boulder as specified herein and in the Geotechnical Report encountered within the limits specified in Section 3.3 or shown in the Drawings, whichever is deeper, shall not be considered as unanticipated.
- J. The Contractor shall submit with the bid documents the quantities used to estimate the lump sum for Unclassified Excavation. Should quantities of certain materials or classes of work be increased or decreased from what is shown in the drawings and specified herein, the Contract Unit Rates listed below shall be the basis of payment to the Contractor, or credit to the Owner, for such increase or decrease in the work. The Contract Unit Rates shall represent the exact net amount, per unit, to be paid to the Contractor in the case of increases in the quantities, and the exact amount to be refunded to the Owner in the case of decreases in the quantities. No additional adjustment shall be allowed for overhead, profit, insurance, or other direct or indirect expenses by the Contractor. Contract Unit Rates of materials shall include processing hauling, storing, stockpiling, moving, importing, spreading, and compacting. Increases or decreases in the quantities shall be approved by the Owner. Should quantities of certain materials or classes of work be increased or decreased from what is shown in the drawings and specified herein, the Contract Unit Rates listed below (see Section 3.6.M) shall be the basis of payment to the Contractor, or credit to the Owner, for such increase or decrease in the work. The Contract Unit Rates shall represent the exact net amount, per unit, to be paid to the Contractor in the case of increases in the quantities, and the exact amount to be refunded to the Owner in the case of decreases in the quantities. No additional adjustment shall be allowed for overhead, profit, insurance, or other direct or indirect expenses by the Contractor. Contract Unit Rates of materials shall include processing, hauling, storing, stockpiling, moving, importing, spreading, and compacting. Increases or decreases in the quantities shall be approved by the Owner.
1. The Contractor shall excavate soil and fill to the limits necessary to achieve the required grades determined by the Architect. The limits of excavation may not coincide with those areas indicated on the Drawings. The excavation areas shown on the Drawings are estimated areas only.
- M. Provide unit process as follows:
1. For each type of material listed in PART 2 - PRODUCTS, separate unit rates shall be provided for imported material and material processed onsite. The unit rates shall include furnishing/processing, stockpiling, placing, and compacting the material)
 2. Provide unit rate for rock excavation in trenches and pits, removed from the site, and any placement of fill required to bring excavated surface to specified subgrade.
 3. Provide unit rate for rock excavation as open excavation, removed from the site, and any placement of fill required to bring excavated surface to specified subgrade.
- N. Unsuitable Soil Allowance for unanticipated Condition: The Contractor shall carry an allowance of cubic yards for excavation and placement/replacement of materials for unanticipated condition as defined in 3.1-B. Allowance shall cover removal and disposal of unsuitable soil and furnishing imported suitable backfill materials compacted in place as directed herein.

1. If the total void volume of unanticipated unsuitable material excavation below specified subgrades, and its replacement with compacted fill exceeds the amount included in the Contract as listed above, the Owner shall pay the excess excavation and replacement at the Unit Rate submitted in the Bid Attachment – Unit Rates Schedule.
 2. If the total quantity of unanticipated unsuitable materials below specified subgrades, and its replacement with compacted fill is less than the amount included in the Contract as listed above, the contract sum will be decreased by the difference in excavation and its replacement multiplied by the Unit Rate submitted in the Bid Attachment – Unit Rates Schedule.
 3. Final excavated surfaces shall be surveyed by the Contractor and shall be measured from specified subgrade to bottom of excavation. Payment shall be based upon actual volumes with no bulking or swell factors applied. Contractor shall submit all survey data and quantity calculations to Architect for approval.
- O. Petroleum Contaminated Soil Allowance: The Contractor shall carry in the base bid an allowance of cubic yards for removal of unanticipated as directed in Section 01 22 00 Unit prices, petroleum contaminated soil materials. Allowance shall cover removal and disposal of petroleum contaminated soil and furnishing imported suitable backfill materials compacted in place as directed herein. The base bid shall cover all costs related to such excavation, removal off site, disposal, and replacement with compacted fill of approved material, overhead, and profit. No amount other than that herein specified will be paid by the Owner for the work defined herein.
1. If the total void volume of unanticipated petroleum contaminated material excavation, and its replacement with compacted fill exceeds the amount included in the Contract as listed above, the Owner shall pay the excess excavation and replacement at the Unit Rate submitted in the Bid Attachment – Unit Rates Schedule.
 2. If the total quantity of unanticipated petroleum contaminated materials, and its replacement with compacted fill is less than the amount included in the Contract as listed above, the contract sum will be decreased by the difference in excavation and its replacement multiplied by the Unit Rate submitted in the Bid Attachment – Unit Rates Schedule.
 3. Final excavated surfaces shall be surveyed by the Contractor and shall be measured from specified subgrade to bottom of excavation. Payment shall be based upon actual volumes with no bulking or swell factors applied. Contractor shall submit all survey data and quantity calculations to Architect for approval.

3.7 ROCK EXCAVATION

- A. Definitions and Classifications: The following classifications of excavation will be made only when rock excavation is required.
1. “Earth Excavation” consists of excavation, removal and disposal of soil, pavement and other obstructions visible on ground surface, underground structures and utilities indicated to be demolished and removed, material of any classification indicated in data on subsurface conditions, and other materials encountered that are not classified as rock excavation.
 2. “Rock Excavation” consists of removal and disposal of materials encountered that cannot be excavated without continuous and systematic drilling and blasting or continuous use of a ripper or other special equipment, except such materials that are classed as earth excavation. Typical of materials classified as rock excavation are as follows:
 - a. Rock or stone in original ledge.
 - b. Hard shale in original ledge.
 - c. Boulders on site, outside trench limits, exceeding three cubic yards in volume.
 - d. Boulders within trench limits, exceeding one cubic yard in volume.

- e. Rock that is blasted and excavated in large pieces shall not be paid for a boulders.
3. Should highly fractured or weathered bedrock be encountered, as observed by Geotechnical Engineer, during excavation, the following shall apply:
 4. When the material is encountered in trenching operations or under footings, it shall be excavated or ripped with a hydraulic excavator equal to or larger than Caterpillar 336 excavator and will be classified as Earth Excavation. When it is demonstrated to the satisfaction of the Architect and the Soils Representative that this material can no longer be removed with a hydraulic backhoe and requires drilling and blasting, this material shall be classified as Rock Excavation. For excavation procedures when this material is encountered under footings, refer to paragraph below.
 5. When this material is encountered in open excavation, it shall be classified as earth excavation until drilling and blasting or continuous ripping is necessary as defined hereinabove.
 6. Intermittent drilling and ripping performed to increase production and not necessary to permit excavation of material encountered will be classified as earth excavation.
 7. The Base Bid shall cover all costs relating to rock excavations within the limits specified herein and shown on the drawings, whichever is deeper, including blasting, removal and placement of the excavated material, overhead and profit. No amount other than that herein specified will be paid by the Owner for excavation herein defined. The Contractor is warned that the site includes large areas of rock outcrops that are not shown in the drawings and geotechnical report. The site contractor is encouraged to make a site visit to assess site conditions before submitting a bid. Also, the access road from the proposed school to Farm Street shown in the geotechnical report has shifted south subsequent to the explorations performed in that area, and is anticipated to encounter rock during excavation not shown in the test pits performed along the proposed access road.
 8. Allowance for Unanticipated Rock Excavation: The Contractor shall carry in the Base Bid an allowance of cubic yards for rock encountered in trench excavation removed from the site for unanticipated condition. The Contractor shall also carry in the Base Bid an allowance of cubic yards for open rock excavation removed from the site for unanticipated condition. Unanticipated condition for rock is where rock was not anticipated or is shallower than shown in the borings and tests pits.
 9. Quantities shall be measured by the volume of void created using survey points obtained by the Contractor of the excavated area. The fixed Unit Rate shall be applicable to variations in excess of the allowance quantity up to 100% of the allowance quantity.
 10. If the total quantity of Rock Excavation, open and/or trench, is less than the amount of Rock Excavation included in allowance above, the Contract sum will be decreased by the difference in Rock Excavation multiplied at the fixed Unit Rate. Quantities shall be measured by the volume of void created using survey points of the excavated area obtained by the Contractor. The fixed Unit Rate shall be applicable to variations of the allowance quantity by decreases or increases of up to 100% of the allowance quantity.
 11. Hoe ramming rock shall be paid for as rock excavation and shall not be paid for as time and material (T&M).
 12. To reduce overblasting and the potential for heaved rock, drill holes for blasting shall not extend more than 2 feet beneath the minimum depths shown above.
 13. Rock blasting, if needed, shall be controlled to reduce vibrations and airblast overpressure to below thresholds established in the contract documents. The peak particle velocity shall be

maintained at less than 2 inches per second (ips) for concrete foundations, 1 ips for stone foundations, and 0.5 ips for rubble foundations at the nearest structure.

14. The Contractor shall carry in the base bid an allowance for installing 1,200 liner feet of 1-1/4-in. (#10) nom. dia. Grade 75 hot-dip galvanized, continuous threadbar by Williams Form Engineering, Dywidag® Systems International of equivalent. The allowance shall include the cost of dowel testing.
15. The contractor shall carry in the base bid an allowance 280 linear ft. of drilled slope drains with a minimum diameter of 3.5 inches the lower (exposed) 5-feet of the hole sleeved with solid wall Sch. 40 PVC and extended 6 inches beyond final slope face.
16. The contractor shall carry an allowance for at four (4) days of a rock slope scaling by professional scaling crew.

B. Measurements

1. Rock quantities within the proposed building footprint, access roadway, and retaining walls, shall be based on difference between surface of top of rock and bottom of rock cut. The surface of top of rock shall be determined before the start of blasting by surveying surface of rock outcrops and by performing probes in rock where rock is below overburden using blasting drill rigs. The probes shall be performed at a grid no more than 50-foot intervals and shall extend at least 10 feet beyond perceived top of rock to make sure that refusal is not on a boulder. Rock probes shall be coordinated with and observed by Geotechnical Engineer and the data submitted to the Owner.
 2. When, during the process of other excavations, unanticipated rock is encountered, such material shall be uncovered and exposed in such a manner that the unbroken ledge surface is clearly visible, and the Architect shall be notified by the Contractor, before proceeding further. The areas in question shall then be cross-sectioned as hereinafter specified.
 3. Failure on the part of the Contractor to uncover such material and to notify the Architect and proceeding by the Contractor with the rock excavation before cross-sections are taken, will forfeit the Contractor's right of claim towards the stated allowance or additional payment over and above the stated allowance at the quoted Unit Rate.
 4. The Contractor shall employ and pay for a Professional Civil Engineer or Land Surveyor registered in the Commonwealth of Massachusetts to take cross-sections of rock before removal and to make computations of volume of rock encountered within the Payment Lines. Cross-sections shall be taken in the presence of the Soils Representative and the computations approved by the Architect. The Owner has the option to perform independent cross-sections and computation of rock quantities.
 5. Where removal of boulder or ledge is required outside the established payment lines, the extent of this removal and basis of payment shall be determined by the Architect.
- C. Rock shall be excavated within the proposed building areas to a depth of at least 5 feet beneath the proposed finished floor elevation or 12 inches beneath the bottom of the footings, whichever is deeper.
- D. The slope angle of rock cuts shall not be steeper than 3V:1H. The number of individual cut slope segments shall be reduced to the fullest extent practical. Reverse curvature cuts shall be minimized, including cuts resulting in "convex" slope profiles.

- E. Spot rock dowels shall be installed at locations determined by the Rock Specialist during project construction. Dowel lengths shall be determined by the Rock Specialist in the field based on post-scaled slope conditions.
- F. Slope drains shall be installed at locations provided by the Rock Specialist based on post-excavation conditions. The slope drains shall be 10- to 20-foot long drains drilled into the rock at a slope of 4H:1V with upward batter.
- G. Perimeter Control Methods and Precision Pre-splitting shall be performed. This shall include reducing the spacing of presplit holes and reducing the charge weights to avoid backbreak and excessive gas travel. Blasthole bore tracing and/or slope scanning shall be implemented to minimize drillhole elevation and produce pre-split holes that do not deviate more than 6 inches out of alignment over the full maximum vertical lift height.
- H. The rock blasting contractor shall be advised that localized silica-rich zones of bedrock may be encountered, and drill bit selection shall take into account the brittle, high strength and abrasive nature of the bedrock. The rock blasting contractor shall also be made aware of the potential for encountering two different lithologies (i.e., rhyodacite and granodiorite). The mapped volcanic and igneous intrusive rocks may behave somewhat differently and require some adjustment of perimeter control blasting technique, especially where lithology changes.
- I. Overburden soils on rock slopes shall be stripped back a minimum of 8 feet from the final slope crest. The overburden soils shall be sloped to a maximum 2H:1V with revegetated slope face and use of geosynthetic matting, if required to maintain the slope and resist erosion.
- J. Trees and vegetation shall be a cut within a minimum of 15 feet of the proposed slope crest.
- K. The rock slope shall be thoroughly scaled during and after development/excavation, as needed based on exposed field conditions and real-time construction safety considerations. Scaling shall be performed by experienced slope high scalers to the satisfaction of the Owner. Use of onsite construction equipment such as back hoes, excavators, or similar, to "scrape" down the final slope face shall not be allowed.
- L. A minimum 12-foot-wide catchment ditch with a 4H:1V fore slope batter shall be installed at the bottom of the rock slope. The catchment ditch shall be fitted with a guardrail or similar to help capture rockfall and to help keep unauthorized persons from entry within the ditch. The catchment ditch shall be backfilled with a minimum of 18-inches of ¾-inch crushed stone. The catchment ditch at the toe of the slope shall direct water away from excavation areas.
- M. Signage shall be provided at the top of the rock slope to warn against falling hazard.
- N. Rock excavation for foundations outside of the Building Areas: Remove rock to 12 inches below foundation or footing subgrade. All rock bottoms for foundations shall be carefully examined. Loose or shaken rock shall be removed to solid bearing, and the rock surface leveled, or shelved to a slope not exceeding one inch per two feet, or as directed.
- O. Prepared rock subgrades shall be compacted with at least four passes of a self-propelled vibratory roller such as Dyna Pac CA-30D (44,000 lbs. Centrifugal force) or equivalent. Rock subgrades in utility trenches shall be recompacted with at least four passes a walk-behind vibratory drum roller or other equivalent equipment having at least 10,000 pounds centrifugal force and sufficient to provide a firm, stable subgrade. Where the surface of the rock is not even, the thin shimming layer of soil shall be placed to provide a level surface before compaction.

- P. If any part of the rock excavation at footings to be carried beyond the depth and the dimensions indicated on the Drawings or called for in the Specifications, the Contractor shall, at his own expense, furnish and install concrete of same strength as footings to the required subgrade level of the footings as shown on the Drawings. Dowelling or other corrective structural measures as directed by the Architect may also be required to properly anchor or reinforce the concrete. If rock excavation is carried beyond the depth and dimensions to subgrade in other areas, the Contractor shall, at his own expense, furnish and install compacted gravel fill to subgrade as directed by the Architect.
- Q. Basis of Payment: The total amount of rock excavation will be based upon the in-situ volume of rock excavated within and/or above the lines referred to in the next paragraph as "Payment Lines". The payment lines are only to be used as a basis of payment and are not to be used as limits of excavation. Limits of excavation area as shown on the Drawings and as specified herein.
- R. Payment Lines for Rock Excavation:
1. Payment lines for buildings shall be 5 feet beneath the finished floor elevation and laterally at least 5 feet beyond the limits of the proposed buildings.
 2. Payment lines for manholes and catch basins shall be one-foot outside of the outer wall and 12 inches beneath the structure.
 3. Payment lines for rock excavation at plant beds shall be 12" at edge and full depth of required elevation for loam.
 4. Payment lines for rock excavation at paved areas and lawns shall be 18 inches below bottom of asphalt for paved areas and below bottom of turf subbase in lawns and athletic fields.
 5. Payment lines for rock excavation under pipes within the buildings and for utility trenches outside the building lines shall in no case be calculated as greater in width than the outside diameter of the pipe plus two feet for pipes up to 18 inches. For pipes 18 inches and larger payment lines shall in no case be calculated as greater in width than the outside diameter of the pipe plus three feet. Payment lines at bottom of all pipe and utility trenches shall be 12 inches below the bottom of the pipe.

3.8 STORAGE OF SOIL MATERIALS - STOCKPILING

- A. The Contractor shall be responsible for managing and tracking any and all materials excavated and placed in stockpiles for testing.
- B. Materials shall be stockpiled on site at locations proposed by the Contractor and approved by the Architect. Stockpiled materials shall be of sufficient quantities to meet project schedule and requirements.
- D. The temporary stockpiled fill must be removed from the Site in accordance with applicable regulatory deadlines however no later than the completion date of this contract or 90 days from the date the stockpile was created, whichever is encountered first.
- E. Stockpiles shall be securely barricaded and clearly labeled. Differing materials shall be separated with dividers or stockpiled apart to prevent mixing.
- F. The Contractor shall direct surface water away from stockpile site to prevent erosion or deterioration of materials. Soils shall be suitably dewatered prior to their relocation on Site or disposal off site.
- G. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.9 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.10 EXCAVATION FOR UTILITY TRENCHES

- B. Excavate trenches to indicated gradients, lines, depths, and elevations.
 - a. Beyond building perimeters, excavate trenches to allow installation of top of pipe below frost line.
- C. Trenches shall be excavated to the necessary width and depth for proper laying of pipe or other utility and excavation side slopes shall conform to OSHA requirements. Minimum width of trenches shall provide clearance between the sides of the trench and the outside face of the utility. Maximum trench sizes are as shown on the Drawings or as specified herein. The depth of the trench shall be twelve inches below the bottom of the pipe barrel or respective utility. If the existing soil at the final subgrade excavation is found not suitable, the Architect or Soils Representative may approve removal and replacement of material.
 - 1. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches (300 mm) higher than top of pipe or conduit, unless otherwise indicated.
 - 2. Clearance: As indicated on plans.
 - 3. For pipes and conduit 6 inches (150 mm) or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe circumference. Fill depressions with tamped sand backfill.
 - 4. Excavate trenches 6 inches (150 mm) deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
- C. The Contractor shall provide, at his own expense, suitable bridges over trenches where required for accommodation and safety of the traveling public and as necessary to satisfy the required permits and codes.

3.11 SUBGRADE INSPECTION, COMPACTION AND PROOF ROLLING

- A. Notify Architect when excavations have reached required subgrade.
- B. Proof compact all subgrades in accordance with Sections 1.2 and 3.3 of these Specifications and the Geotechnical Report to identify soft pockets and areas of excess yielding. Do not proof compact wet or saturated subgrades.
 - 1. Completely proof compact subgrade in one direction repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph (5 km/h).
 - 2. Revise minimum weight or type of vehicle in first subparagraph below if required.
 - 3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect and/or Soil Representative, and replace with compacted fill as directed.
 - 4. Proof compacting shall be completed utilizing a 20-Ton vibratory drum roller for granular soils. Should clay or other cohesive soils be encountered, sheep's foot roller shall be utilized. A total of 6 passes shall be considered complete.

- C. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect and/or soil representative, without additional compensation.

3.12 BACKFILL

- A. Place and compact backfill in excavations promptly, but not before completing the following:
 - 1. Construction below finish grade including, where applicable, subdrainage,
 - 2. Surveying locations of underground utilities for Record Documents.
 - 3. Testing and inspecting underground utilities.
 - 4. Removing concrete formwork.
 - 5. Removing trash and debris.
 - 6. Removing temporary shoring and bracing and sheeting.
- B. If, through failure or neglect of the Contractor to conduct the excavation work in a proper manner, the surface of the subgrade is in an unsuitable condition for proceeding with construction, the Contractor shall, at his own expense, remove the unsuitable material and replace it. Failure of the Contractor to control surface or ground water adequately, premature excavation at the work site, or other manifestations of the Contractor's neglect or improper conduct of the work, as determined by the Architect, shall be grounds for requiring removal and replacement of unsuitable subgrade without additional compensation.
- C. Grading in the vicinity of backfilling shall be properly pitched to prevent water from running into the backfilled area. Work areas shall be kept free from water during performance of the work under this Contract at no expense to the Architect. The Contractor shall build diversion berms and other devices necessary for this purpose.
- D. The Contractor shall not commence backfilling operations until the Architect gives approval.
- E. After the subgrade has been prepared, fill material shall be placed and built-up in successive layers until the required elevations are reached. No fill shall be placed on a frozen surface, nor shall snow, ice, or other frozen material be included in fill. Wet materials containing moisture in excess of the amount necessary for satisfactory placement or compaction shall not be used.
- F. All fill shall be brought up in essentially level lifts and shall be placed in levels by standard methods. The method of placement shall not disturb or damage other work. Layers of fill shall not exceed twelve inches of uncompacted thickness before compaction, unless otherwise specified or as necessary for proper subgrade stabilization.
- G. Place backfill on subgrades free of mud, frost, snow, or ice.
- H. Filling operations shall continue until the fill has been brought up to the finished slopes, lines, and grades making proper allowances for thickness of surface treatment.
- I. The entire surface of the work shall be maintained free from ruts and in a condition that will permit construction equipment to travel readily over any Section. The top surface of each layer shall be made level or slightly sloped away from the center of the filled area. Fills shall be graded to drain and compacted/sealed whenever precipitation is expected.
- J. Backfilling shall not be performed when weather conditions or the conditions of the material are such that, in the opinion of the Architect, work cannot be performed satisfactorily.

3.13 ACCEPTABLE BACKFILL MATERIALS

A. Backfill materials shall be placed in the areas as indicated in the table below:

Fill below footings, including site retaining walls, below slabs, and below the under-slab drainage system within the Building Area	Structural Fill
Fill for under-slab drainage system	3/4-inch Crushed Stone over geotextile fabric
Fill around footings for building and structures within the Influence zone	Structural Fill
Fill below pavement subbase	Ordinary Fill
Fill below sidewalk subbase	Ordinary Fill
Fill placed in top 1 foot below sidewalks, walkways, rubber play areas, exterior stairs, unheated and exterior slabs and pads	Select Fill
Fill beneath paved areas (Subbase)	Dense Graded crushed Stone for Subbase
Fill within utility trenches below pavement and sidewalk subbase	Ordinary Fill
Fill below utility bedding	Ordinary Fill
Fill placed in landscaped areas outside of the Influence Area of footings, retaining walls, and slopes, and at depths greater than 3 feet in paved areas	Common Borrow
Fill placed around banks of pipes	Sand Fill
Under site retaining walls and hardscape features	Structural Fill

3.14 UTILITY TRENCH BACKFILL

- A. Place backfill on subgrades free of mud, frost, snow, or ice.
- B. Place and compact bedding on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- C. Place and compact initial backfill material, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the utility pipe or conduit.
 - 1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

- D. Backfill voids with satisfactory soil while installing and removing shoring and bracing.
- E. Place and compact final backfill of satisfactory soil to final subgrade elevation.
- F. Backfill voids with approved backfill material while installing and removing shoring and bracing. Where voids cannot be backfilled with compacted backfill, the voids shall be filled with flowable fill.
- G. Backfilling around banks of pipes shall be performed by chinking the Sand Fill with hand shovel and pouring water on the backfill material (Sand Fill) to fill the voids.
- H. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.15 BELOW GRADE TANK BACKFILL

- A. Backfill with Pea Gravel as specified herein. The use of the proper material is critical to the long-term tank performance.
- B. Do not mix approved backfill material with sand or native materials. Do not backfill tank with sand or native materials.
- C. Replace all excavated native materials with approved Pea Gravel which meets ASTM C 33 for quality and soundness.

3.16 SOIL FILL

- A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
 - 1. Sequentially place and compact fill material in layers to required elevations.
- B. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.17 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
 - 1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
 - 2. Remove and replace or scarify and air dry otherwise satisfactory soil material that exceeds optimum moisture content by +3 to -3 percent and is too wet to compact to specified dry unit weight.
 - 3. If in the opinion of the Architect or Geotechnical Engineer, additional moisture is required, water shall be applied by sprinkler tanks or other uniform distribution devices. If excessive amounts of water or if rain should cause excessive wetness, the area shall be allowed to dry as provided above.

3.18 GRADING

- A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross Sections, lines, and elevations indicated. Grading shall be done by standard methods. Areas adjacent to structures and other areas inaccessible to heavy

grading equipment shall be graded by manual methods. Embankments shall be graded at all times to ensure runoff of water.

1. Provide a smooth transition between adjacent existing grades and new grades.
 2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
 3. Provide proper drainage from the site, no grading shall be done to direct water to damage or potentially damage adjacent property or work executed under this contract.
- B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
1. Lawn or Unpaved Areas: Plus or minus **[1 inch]**
 2. Walks: Plus or minus **[1 inch]**
 3. Pavements: Plus or minus **[1/2 inch]**

3.19 FIELD QUALITY CONTROL

- A. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.
- B. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed in accordance with Section 1.7 and 1.20 of this Specification Section and:
1. Paved Areas: At subgrade and at each compacted fill and backfill layer, at least 1 test for every 500 sq. ft. or less of paved area, but in no case fewer than 3 tests.
 2. Trench Backfill: At each compacted initial and final backfill layer, at least 1 test for each 150 feet or less of trench length, but no fewer than 2 tests.
- C. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth required; recompact and retest until specified compaction is obtained.
- D. The contractor shall engage an independent testing agency, acceptable to authorities having jurisdiction, experienced in seismic surveys and blasting procedures to perform seismographic monitoring services during blasting operations

3.20 COMPACTION REQUIREMENTS

- A. The following table lists minimum compactive efforts, which are required for all, fill materials. Compaction of each lift shall be completed before placement and compaction of the next lift is started. The compaction equipment shall make an equal number of transverse and longitudinal coverages of each lift. The degree of compaction for fill placed in various areas shall be as follows:
- | | |
|--|-----|
| 1. Under concrete slabs and footings | 95% |
| 2. In paved areas | |
| Within aggregate base course | 95% |
| Within aggregate subbase course | 95% |
| Below subbase course | 95% |
| 3. In landscaped areas (To be checked/approved by RLA) | 90% |
| 4. Around and Above Utilities below | |

Below Pavement subbase in paved areas 95%

*Percentage of maximum dry density of the materials at optimum moisture content as determined by methods or tests for ASTM designation D1551 Method D.

- B. Compaction shall be accomplished by vibratory rollers, multiple wheel pneumatic tired rollers or other types of approved compacting equipment. Loaded trucks, low beds, water wagons and the like shall not be considered as acceptable compaction equipment unless specifically approved by the Architect for a particular location. Equipment shall be of any such design that it will be able to compact the fill to the specified density in a reasonable length of time. All compaction equipment shall be subject to the approval of the Architect.
- C. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
- D. Backfill shall not be placed against walls until they are braced or have cured sufficiently to develop strength necessary to withstand, without damage, pressure from backfilling and compacting operations.
- E. Before backfilling against walls, the permanent structures must be completed and sufficiently aged to attain strength required to resist backfill pressures without damage. Temporary bracing will not be permitted except by written permission from the Architect. Correct any damage to the structure caused by backfilling operations at no cost to the Owner.
- F. During backfilling, the difference in elevation of backfill on opposite sides of the structure shall not exceed 24 inches, except as noted. Where backfill of wall is only on one side, only hand-operated roller or plate compactors shall be used within a lateral distance of 5 feet of back of wall for walls less than 15 feet high and within 10 feet of back of wall for walls more than 15 feet high. The backfill material shall be compacted with a dynamic vibratory compactor weighing no more than 1000 pounds and imparting a minimum of no more than 8 kips of force to the subgrade.
- G. The Contractor shall compact all fills made during the day of work prior to leaving the project for the evening. The upper layer shall be pitched as necessary to provide positive drainage towards swales or interceptor ditches to minimize ponding and erosion should it rain.

3.21 COMPACTION TESTING

- A. The Contractor shall make all necessary excavations and preparations for testing. Excavations for density tests shall be backfilled with material similar to that excavated, and compacted to the specified density by the Contractor. Failure of the backfill material to achieve the specified density will be just cause for rejection of any or all portions of the excavation Section tested. The Contractor will not be granted an extension of time or additional compensation for testing or repair of backfill ordered by the Architect.
- B. Field density tests will be made by the Owner's Inspection Agency in accordance with the Method of Test for ASTM Designation D1556 or D6938, to determine adequacy of compaction; the location and frequency of such field tests shall be at the Architect's Inspection Agency's discretion.
- C. All field density tests results shall be reviewed by the Architect prior to the placement of concrete.
- D. The Contractor shall notify the Inspection Agency when an area is ready for compaction testing. This notification shall be 48 hours in advance of placing or final compaction so that the Architect Inspection Agency has adequate time to take compaction tests.

- E. Cooperate with the Architect in obtaining field samples of in-place materials after compaction. Furnish incidental field labor in connection with these tests. The Contractor will be informed by the Architect of areas of unsatisfactory density which may require improvements by removal and replacement, or by scarifying, aerating, sprinkling (as needed), and recompaction prior to the placement of the new lift. No additional compensation shall be paid for work required to achieve proper compaction.
- F. The Owner or Architect's Inspection Agency's presence does not include supervision or direction of the actual work by the Contractor, his employees, or agents. Neither the presence of the Inspection Agency nor any observations and testing performed by him shall excuse the Contractor from defects discovered in his work.

3.22 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
 - 1. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
- B. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.
 - 1. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
 - 2. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.23 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Project property.

3.24 REMOVAL OF EROSION CONTROL MEASURES

- A. Remove temporary drainage swales, check dams, siltation sumps, hay bales, siltation fencing and other temporary drainage, erosion and siltation control measures when permanent drainage control measures have been installed and grass is established in drainage areas leading to siltation sumps. Contractor shall excavate and remove all sediments from siltation sumps prior to backfilling the sumps. Remove erosion control measures when approved by the Architect.

End of Section

SECTION 312500
EROSION AND SEDIMENTATION CONTROLS

PART 1-GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

- A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:
 - 1. Control measures to prevent all erosion, siltation, and sedimentation of wetlands, waterways, construction areas, adjacent areas and off-site areas.
 - 2. Control measures shall be accomplished adjacent to or in the following work areas:
 - a. Soil stockpiles and on-site storage and staging areas.
 - b. Cut and fill slopes and other stripped and graded areas.
 - c. Constructed and existing swales and ditches.
 - d. Retention ponds.
 - e. At edge of wetlands areas, if applicable, as shown on Drawings.
 - 3. The Contract Drawings indicate the minimum requirements for erosion and sedimentation control. The Contractor shall install all measures needed to control erosion and sediment as required by the Contractor and Sub-contractor's construction methods and operations, the weather conditions, and as directed by the Engineer.
 - 4. Additional means of protection shall be provided by the Contractor as required for continued or unforeseen erosion problems, at no additional cost to the Owner.
 - 5. Periodic maintenance of all sediment control structures shall be provided to ensure intended purpose is accomplished. Sediment control measures shall be in working condition at the end of each day.
 - 6. After any significant rainfall, sediment control structures shall be inspected for integrity. Any damaged device shall be corrected immediately.
- B. Alternates: Not Applicable.
- C. Items to Be Installed Only: Not Applicable.
- D. Items to Be Furnished Only: Not Applicable.
- E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
 - 1. Section 311000 – SITE CLEARING for protection of existing trees and other vegetation to remain.
 - 2. Section 312000 – EARTH MOVING for soil materials, excavating, backfilling, and site grading and removal of site utilities.

1.3 SUBMITTALS

- A. Refer to Section 013300 – SUBMITTAL PROCEDURES, for submittal provisions and procedures.
 - 1. At least 20 days prior to the start of the project, the Contractor shall submit an Appendix by a qualified person to the Draft Stormwater Pollution Prevention Plan (SWPPP) indicating project phasing, Contractor operation areas, work areas, stockpile locations, construction staging/sequencing, and sedimentation and erosion control measures to be used. This Appendix shall become part of the SWPPP that is to be updated and maintained by the Contractor.
 - 2. As part of the Contract Closeout procedures, the Contractor is responsible for filing a Notice of Termination with the EPA once the project has been completed and is permanently stabilized. Stabilization is complete when all temporary storm water and erosion controls have been removed, all permanent storm water and erosion controls are in place and functional and all vegetated areas are at least 70% viable.
 - 3. The Contractor shall provide the manufacturer's literature, material specification, and installation instructions for sedimentation and erosion control materials and devices for approval. Do not order materials until approval of certifications or test results has been obtained. Delivered materials shall match the approved submittals.
 - 4. LEED Submittals: Submit LEED supporting documentation as outlined in Section 018110 SUSTAINABLE DESIGN REQUIREMENTS for materials and products that have been extracted, harvested, or recovered, as well as manufactured within 500 miles of the project site.

1.4 QUALITY ASSURANCE

- A. When applicable, comply with the requirements of Stormwater Pollution Prevention Plan prepared for the NPDES permit, which are incorporated herein by reference, and all other applicable requirements of governing authorities having jurisdiction. The specifications and drawings are not represented as being comprehensive, but rather convey the intent to provide complete slope protection and erosion control for both the project site and adjacent property.
 - 1. Provide temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to a sediment and erosion control plan specific to the site, that complies with EPA 832/R-92-005 or requirements of authorities having jurisdiction, whichever is more stringent.
- B. Erosion control measures shall be established at the beginning of construction and maintained during the entire period of construction. On-site areas which are subject to severe erosion, and off-site areas which are especially vulnerable to damage from erosion and/or sedimentation, are to be identified and receive special attention.
- C. The Contractor shall install and maintain sedimentation control devices during construction to prevent the movement of sediment from the construction site to off site areas, into adjacent water bodies via surface runoff or into underground drainage systems. Measures to prevent the movement of sediment off site shall be installed, maintained, removed, and cleaned up at no additional cost to the Owner.
- D. All land-disturbing activities are to be planned and conducted to minimize the size of the area to be exposed at any one time, and the length of time of exposure.
- E. Surface water runoff originating upgrade of exposed areas should be controlled to reduce erosion and sediment loss during the period of exposure.

- F. When the increase in the peak rates and velocity of storm water runoff resulting from a land-disturbing activity is sufficient to cause accelerated erosion of the receiving stream bed, provide measures to control both the velocity and rate of release so as to minimize accelerated erosion and increased sedimentation of the stream.
- G. All land-disturbing activities are to be planned and conducted so as to minimize off-site sedimentation damage.
- H. The Contractor is responsible for cleaning out and disposing of all sediment once the storage capacity of the sediment facility is reduced by one-half.
- I. Inspect, repair, and maintain erosion and sedimentation control measures during construction until permanent vegetation has been established.
- J. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

1.5 REFERENCE STANDARDS

- A. The following standards are applicable to the work of this Section to the extent referenced herein:
 - 1. "Massachusetts Erosion and Sedimentation Control Guidelines for Urban and Suburban Areas, A Guide for Planners, Designers and Municipal Officials", prepared by the Massachusetts Department of Environmental Protection, Bureau of Resource Protection, dated March 1997, reprinted May 2003.
 - 2. United States Environmental Protection's (EPA) National Pollutant Discharge Elimination System (NPDES) Construction General Permit for Stormwater Discharges from Construction Activities (CGP).

1.6 EXAMINATION OF SITE AND DOCUMENTS

- A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation of the site.
- B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for themselves during the bidding period and formed their own conclusions as to the full requirements of the work involved.

1.7 PERMITS, CODES, AND REGULATIONS

- A. Comply with all rules, regulations, laws, and ordinances of the City and State, and all other authorities having jurisdiction over the project site. All labor, materials, equipment, and services necessary to make the work comply with such requirements shall be provided by the Contractor without additional cost to the Owner.
- B. Comply with all applicable regulations of the Commonwealth of Massachusetts Department of Environmental Protection (DEP) and the EPA.
- C. The Contractor shall comply with the requirements of the NPDES CGP for this project.
- D. Comply with all requirements of the Order of Conditions issued by the Wakefield Conservation Commission for the project.

1.8 STORM WATER POLLUTION PREVENTION PLAN

- A. A professional engineer has prepared a Draft Storm Water Pollution Prevention Plan (SWPPP). The Contractor shall locate the SWPPP and review its contents thoroughly. Upon the award of the Contract, the Contractor becomes responsible for implementing the SWPPP and meeting the requirements and standards detailed within the SWPPP. The Contractor is also responsible for all record keeping associated with maintaining the SWPPP and for maintaining in good operating condition all SWPPP controls. The Contractor shall modify the SWPPP as necessary to reflect changes in project scope, schedule, or approach. All labor, materials, equipment, and services necessary to make the work comply with such requirements shall be provided by the Contractor without additional cost to the Owner.
- B. The Contractor shall fill out all pertinent information within the SWPPP.
- C. The Contractor shall locate the EPA "Notice of Intent for Storm Water Discharges Associated with CONSTRUCTION ACTIVITY Under a NPDES General Permit" (NOI) form in the SWPPP. The Contractor is responsible for signing and filing his copy of the NOI at least 14 calendar days prior to the start of any construction activity and placing a signed copy along with proof of mailing in the SWPPP.
- D. The Contractor is responsible for obtaining a copy of the Owner's filed copy of the NOI form and proof of mailing and placing it in the SWPPP.
- E. The Contractor is responsible for filling in the Contractor and Sub-Contractor information in the areas indicated within the SWPPP and for completing the Contractor's Certification portion of the SWPPP.
- F. The Contractor is responsible for maintaining the following records on site:
 - 1. Completed SWPPP as indicated in sections B, C, D, and E.
 - 2. Completed Inspection Reports
 - 3. Completed Maintenance Reports
 - 4. Construction Activity Reports
 - 5. Spill Records
 - 6. Other Materials relevant to the NOI Permit and SWPPP
 - 7. A copy of the Notice of Termination
- G. The Contractor is responsible for filing a Notice of Termination once the project has been completed and is permanently stabilized. Stabilization is complete when all temporary storm water and erosion controls have been removed, all permanent storm water and erosion controls are in place and functional and all vegetated areas are at least 70% viable.
- H. All labor, materials, equipment, and services necessary to make the work comply with the above requirements shall be provided by the Contractor without additional cost to the Owner.

PART 2-PRODUCTS

2.1 MATERIALS

- A. Straw Bales: Wire or nylon bound bales of straw, oriented around sides, rather than over and under.

- B. Stakes: Stakes for bales shall be one of the following materials: Wood stakes of sound hardwood 2 by 2 inches in size or steel reinforcing bars of at least No. 4 size. Lengths shall be approximately three feet.
- C. Straw Wattles
1. Straw wattles shall consist of weed free rice straw inside biodegradable netting. Straw wattles shall measure at least nine (9) inches in diameter.
 2. Stakes for wattles shall be one of the following materials. Lengths shall be approximately two feet (2').
 - a. Wood stakes of sound hardwood, one inch by one inch (1" x 1") in size.
 - b. Steel reinforcing bars of at least No. 4 size.
- D. Siltation Fence
1. Fabricated or prefabricated unit consisting of the following filter fabric properties:

a. Grab Tensile Strength (lbs)	124	ASTM D4632
b. Elongation at Failure (%)	15	ASTM D4632
c. Mullen Burst Strength (PSI)	280-300	ASTM D3786
d. Puncture Strength (lbs)	60-65	ASTM D4833
e. Water Flow Rate (gal/min/sf)	8-10	ASTM D4491
f. Apparent Opening Size (Sieve)	30	ASTM D4751
g. Ultraviolet Radiation Stability (%)	70-80	ASTM D4355
 2. Use only commercially available fabric that is certified in writing by the manufacturer for the purpose intended.
 3. Acceptable fabric materials include "Mirafi Envirofence" by Mirafi Construction Products, "Style 2130" by Amoco Fabrics Co., and "IVI 3617C Silt Fence" by Indian Valley Industries, Inc., or approved equal by the Engineer.
 4. Silt fence posts: Posts may be wood or metal. Wood post shall be a minimum 1¼ inch by 1¼ inch by 5 feet long hardwood stakes commonly used to support siltation fabric. Metal posts shall be a minimum of 1 inch wide and 5 feet long. Posts shall be spaced at a maximum distance of 8 feet on center.
 5. Provide suitable heavy nylon cord for securing abutting silt fence posts.
- E. Fencing: Steel posts shall be standard 6-foot long metal stamped drive stakes commonly used to support snow fences. Fencing shall be new four-foot height wood lath snow fencing. Provide suitable steel staples or heavy nylon cord for securing filter cloth to support system.
- F. Crushed Stone: Crushed stone shall consist of durable crushed rock or durable crushed gravel stone, free from ice and snow, sand, clay, loam, or other deleterious or organic material. The crushed stone shall be uniformly blended and shall conform to the following requirements.

Percent Passing by Weight		
Sieve Size	1 1/2-inch Stone	3/4-inch Stone
2-inch	100	---
1 1/2-inch	95-100	---

Percent Passing by Weight		
Sieve Size	1 1/2-inch Stone	3/4-inch Stone
1 1/4-inch	---	---
1-inch	35-70	100
3/4-inch	0-25	90-100
1/2-inch	---	10-50
3/8-inch	---	0-20
No. 4	---	0-5

- G. Protective Measures: As temporary coverings on ground areas subject to erosion, provide one of the following protective measures, and as directed by the Designer with concurrence of the Owner's Representative:
1. Hay or straw temporary mulch, 100 pounds per 1,000 square feet.
 2. Wood fiber cellulose temporary mulch, 35 pounds per 1,000 square feet.
 3. Tackifier for anchoring mulch or straw shall be a non-petroleum based liquid bonding agent specifically made for anchoring hay or straw.
 4. Provide natural (jute, wood excelsior) or man-made (glass fiber) covering with suitable staples or anchors to secure to ground surface. Note that wire staples and non-biodegradable coverings shall not be used for any area that will be mown turf.
 5. Temporary vegetative cover for graded areas shall be undamaged, air dry threshed straw or hay free of undesirable weed seed.
- H. Temporary Covers for Drainage Structures
1. Filter fabric for use as temporary covers for drainage structures shall be the same as noted above for siltation fence.
 2. Wire mesh for use at temporary drainage structure covers shall be 6" x 6", W2.9 welded wire mesh.
 3. Crushed stone shall be as specified herein before.
 4. Silt-Sac, Hydro-FloGard + Plus Catch Basin Insert, Ultra-DrainGuard Insert, or approved equal, may be used in lieu of hay bales and filter fabric at catch basins.

PART 3-EXECUTION

3.1 GENERAL REQUIREMENTS

- A. The Contractor shall provide suitable and adequate means of sedimentation and erosion control during construction. Control measures shall prevent all erosion, siltation, and sedimentation of waterways, drainage systems, construction areas, adjacent areas and off-site areas. Work shall be accomplished on and/or adjacent to the following work areas:
1. Earthwork stockpiles and on-site storage and staging areas.
 2. Cut and fill slopes and other stripped and exposed graded areas.
 3. Constructed and existing swales and ditches.
 4. Unestablished lawns and seeded embankments.

- B. Means of protection as noted on the Contract Drawings indicate the minimum provisions necessary. Additional means of protection shall be provided by the Contractor as required for continued or unforeseen erosion problems, at no additional cost to the Owner.
- C. Periodic maintenance of all sediment control installations shall be provided to ensure intended purposes are accomplished. Sediment control measures shall be in working condition at the end of each day.
- D. After any significant rainfall, sediment control devices shall be inspected for integrity. Any damaged device shall be corrected immediately.
- E. The Contractor shall provide adequate means of control of runoff, as to not detrimentally impact downstream conditions during construction. The Contractor shall plan his operations so that permanent drainage mitigation systems such as detention/retention/infiltration basins and chambers are in place and properly functioning prior to connecting upland drainage flows to these systems. The Contractor shall plan his operations such that downstream drainage mitigation measures are in place and functioning before attempting to tie in upgradient drainage systems.
- F. In the event that the Contractor is unable to sequence the work so that construction of the permanent drainage mitigation systems precedes the upland work, then the Contractor shall submit a plan indicating his proposed methods of otherwise controlling runoff from the site.
- G. The "Massachusetts Erosion and Sedimentation Control Guidelines for Urban and Suburban Areas" should be consulted as a guide for the selection and installation of Best Management Practices to suit the conditions encountered.

3.2 STRAW BALE BARRIERS

- A. Excavation shall be to the width of the bale and the length of the proposed barrier to a minimum depth of 4 inches.
- B. Bales shall be placed in a single row, lengthwise on proposed line, with ends of adjacent bales tightly abutting one another. In swales and ditches, the barrier shall extend to such a length that the bottoms of the end bales are higher in elevation than the top of the lowest middle bale.
- C. Staking shall be accomplished to securely anchor bales by driving at least two stakes or rebars through each bale to a minimum depth of 18 inches.
- D. The gaps between bales shall be filled by wedging straw in the gaps to prevent water from escaping between the bales.
- E. The excavated soil shall be backfilled against the barrier. Backfill shall conform to ground level on the downhill side and shall be built up to 4 inches on the uphill side. Loose straw shall then be scattered over the area immediately uphill from a straw barrier.
- F. Inspection shall be frequent and repair or replacement shall be made promptly as needed.
- G. Bales shall be removed when they have served their usefulness so as not to block or impede stormwater flows or drainage.

3.3 STRAW WATTLE BARRIERS

- A. Install straw wattles as indicated on Contract Drawings and as directed.
 - 1. Wattles shall be placed in a row with ends overlapping a minimum of two (2) feet.

2. Each wattle shall be embedded in the soil a minimum of two (2) and a maximum of six (6) inches.
3. Wattles shall be securely anchored in place by stakes or rebars driven through the wattles and a minimum twelve (12) inches into the soil. Stakes shall be placed four (4) feet on center.

- B. Inspection shall be frequent and repair or replacement shall be made as needed.
- C. Wattles shall be removed when they have served their usefulness so as not to block or impede stormwater flows or drainage.

3.4 STABILIZED CONSTRUCTION ENTRANCE AND STONE BERMS

- A. Stone size: Use ASTM designation C-33, size No. 2 (1-1/2" to 2-1/2"). Use crushed stone.
- B. Length: As effective, but not less than 50 feet.
- C. Thickness: Not less than eight inches.
- D. Width: Not less than full width of all points of ingress or egress, but not less than 25 feet.
- E. Washing: When necessary, wheels shall be cleaned to remove sediment prior to entrance onto public right-of-way. When washing is required, it shall be done on an area stabilized with crushed stone which drains into an approved sediment trap or sediment basin. All sediment shall be prevented from entering any storm drain, ditch, or watercourse through the use of sand bags, gravel boards or other approved methods.
- F. Maintenance: The entrance shall be maintained in a condition which will prevent tracking or flowing of sediment onto public rights-of-way. This may require periodic top dressing with additional stone as conditions demand and repair and/or cleanout of any measures used to trap sediment. All sediment spoiled, dropped, washed or tracked onto public rights-of-way must be removed immediately.
- G. Place crushed stone berms in locations required and as directed. Berms shall have side slopes of 1:3 or less.
- H. Inspect stone berms periodically and replace and/or regrade crushed stone as required.

3.5 SILT FENCING

- A. Excavate a 6-inch trench along the upstream side of the desired fence location.
- B. Drive fence posts a minimum of 1'-6" into the ground. Install fence, well-staked at maximum eight-foot intervals in locations as shown on Drawings. Secure fabric to fence and bury fabric end within the six-inch deep trench cut.
- C. Lay lower 12 inches of silt fence into the trench, 6 inches deep and 6 inches wide. Backfill trench and compact.
- D. Overlap joints in fabric at post to prevent leakage of silt at seam.
- E. Inspect siltation fence after major storm events and periodically and remove accumulated sediment and debris. If a breach or failure of the siltation fence occurs, the fence shall immediately be restored.

3.6 EROSION CONTROL GRASSING

- A. Grassing shall be applied according to the Massachusetts Erosion and Sedimentation Control Guidelines for Urban and Suburban Areas, A Guide for Planners, Designers and Municipal Officials.

3.7 INLET PROTECTION

- A. Install silt fence or straw bales around inlet as specified herein.
- B. Install temporary covers at drainage structure locations that may be subject to erosion infiltration and as directed by the Engineer.
- C. Inspect drainage structures periodically. Remove sediment accumulation and regrade or replace materials as required.

3.8 DUST CONTROL

- A. Throughout the construction period the Contractor shall carry on an active program for the control of fugitive dust within all site construction zones, or areas disturbed as a result of construction. Control methods shall include the following: Apply calcium chloride at a uniform rate of one and one-half (1 ½) pounds per square yard in areas subject to blowing. For emergency control of dust apply water to affected areas. The source of supply and the method of application for water are the responsibility of the contractor.
- B. The frequency and methods of application for fugitive dust control shall be as directed by the Designer with concurrence by the Owner's Representative.

3.9 TEMPORARY PROTECTIVE COVERINGS

- A. Place temporary soil coverings to control erosion and sedimentation on all disturbed or graded areas as required by the construction methods employed and as directed by the Engineer. Erosion control matting shall be installed in all areas seeded or hydroseeded with slopes of one vertical foot to three-foot horizontal, or steeper, immediately after such areas have been seeded and a hay mulch applied as follows:
 - 1. The area to receive matting shall have been recently seeded and shall have a smooth surface free from stones, clods or depressions.
 - 2. Roll out of the matting perpendicular to the slope, do not stretch the fabric. In drainage swales, center the fabric along the flow line. Install the matting in a check slot at the top and bottom of the slope and at the edges of the area to be covered. Check slots shall be six inches deep and six inches wide. Fabric shall extend down one wall of the check slot and across the full width of the base. Overlap edges of matting rolls four (4) inches minimum and overlap the ends eighteen (18) inches minimum.
 - 3. Install staples in check slots, edges, center, and ends of rolls by driving specified steel staples two feet on center over the entire area to be covered except at check slots and ends of rolls, where staples shall be placed six inches on center. All staples shall be driven below finished grade.
 - 4. Fill check slots with loam and tamp firmly.
 - 5. Reseed check slots and all disturbed areas per Specifications.
 - 6. Following matting installation, roll the entire area with a smooth drum roller weighing between fifty and seventy-five (50-75) pounds per linear foot of roller. The finished installation of

matting shall be firmly in contact with the seeded area and provide a smooth, finished appearance free from lumps or depressions.

- B. Install erosion control matting as a temporary ground cover in all disturbed or graded areas subject to erosion and as directed by the Engineer. The temporary ground cover shall protect the site from erosion until a full permanent lawn can be installed. Install and anchor in place temporary erosion control matting in accordance with manufacturer's printed instructions or as directed by the Engineer and remove all temporary erosion control matting prior to installation of a permanent lawn.

- C. Inspect protective coverings periodically and reset or replace materials as required.

3.10 TEMPORARY PROTECTIVE COVERINGS (AFTER GROWING SEASON)

- A. Place temporary covering for erosion and sedimentation control on all areas that have been graded and left exposed after October 30. Contractor shall have the choice to use either or both of the methods described herein.
- B. Hay or straw shall be anchored in-place by one of the following methods and as approved by the Designer with concurrence by the Owner's Representative: Mechanical "crimping" with a tractor drawn device specifically devised to cut mulch into top two inches of soil surface or application of non-petroleum based liquid tackifier, applied at a rate and in accordance with manufacturer's instructions for specific mulch material utilized.
- C. Placement of mesh or blanket matting and anchoring in place shall be in accordance with manufacturer's printed instructions.
- D. Inspect protective coverings periodically and reset or replace materials as required.

3.11 REMOVAL AND FINAL CLEANUP

- A. Once the site has been fully stabilized against erosion, and with the approval of the Owner's Representative remove sediment control devices and all accumulated silt. Dispose of silt and waste materials offsite. Regrade all areas disturbed during this process and stabilize against erosion with surfacing materials as indicated.

END OF SECTION

SECTION 32 12 16
ASPHALT PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions, Division 0 and Division 1, General Requirements, apply to the work of this Section.

1.2 DESCRIPTION OF WORK

- A. The work of this Section consists of providing all labor, equipment, materials, incidental work, and construction methods necessary to furnish and install ASPHALT PAVING, as indicated on the Contract Documents and as specified herein.
- B. The work of this Section includes, but is not limited to the following:
 - 1. Gravel base course construction.
 - 2. New asphalt paving at roadways and walkways.
 - 3. New asphalt paving at Tennis Courts.
 - 4. New asphalt paving at Running Track.
 - 5. Bituminous materials.
 - 6. Patching and resurfacing disturbed paved areas.
 - 7. Pavement markings (Including temporary pavement markings).
- C. Sustainable Building Requirements:
 - 1. The Contractor is to implement practices and procedures to meet the project's sustainable performance goals, which include achieving LEED v4 Silver certification based on USGBC's "LEED Version 4 for Building Design and Construction: Schools" (LEED v4 BD+C: Schools).
 - 2. The work of this Section includes responding to Architect or Contractor requests for additional information or product data and may be required following initial Green Building Certification Institute (GBCI) review of LEED Application.
 - 3. Product substitution requests are subject to additional LEED submittal requirements including, but not limited to, Environmental Product Declarations (EPD), Health Product Declarations (HPD), and General Emissions Testing.

1.3 RELATED WORK

- A. Carefully examine all the Contract Documents for requirements that affect the work of this Section. Other specification sections that directly relate to the work of this Section include, but are not limited to the following:
 - 1. Section 311000 – Site Clearing and Preparation.
 - 2. Section 312000 – Earthwork.
 - 3. Section 321600 – Curbing.
 - 4. Section 321823.39 – Resilient Sport Surfacing.
 - 5. Section 321823.43 – Recreational Court Surfacing.
 - 6. Section 323000 - Site Improvements.

- 7. Section 323100 - Fencing.
- 8. Section 331000 - Water Utilities.
- 9. Section 333000 - Sanitary Sewerage Utilities.
- 10. Section 334000 - Storm Drainage Utilities.

1.4 SUBMITTALS

- D. At least 30 days prior to intended use, submit material certificates signed by material producer and Contractor indicating that products comply with requirements. Provide master mix formula for all asphalt paving specified in this Section with a description of mix ingredients, proportions and aggregate gradation for review and approval.
- E. The asphalt supplier shall certify the tennis court top course submittal shall certify the mix shall be produced with 100 percent stone aggregate and no recycled asphalt pavement (RAP).
- C. Do not order materials until Architect's approval of mix formula has been obtained. Delivered materials shall conform to the approved samples.
- D. Submit product data for pavement marking paint.

1.5 PROJECT CONDITIONS

- A. Weather: Perform work only when existing and forecasted weather conditions are within the limits established by referenced standards. Perform work only when ambient temperature is forecasted to be at least 50-degrees Fahrenheit and when temperatures have not been below 35-degrees Fahrenheit for 12 hours immediately prior to application. Do not apply when base is wet or contains an excess amount of moisture or is in a frozen state.
- B. Asphalt paving shall not be applied until the finished compacted gravel base has been tested and approved. A delay in paving after the gravel base is tested and approved may require re-compaction and testing at no additional cost to the Owner.
- C. Construction methods, transportation and delivery of mixtures, spreading, finishing, compaction joints, etc. shall conform to Section 460 of the Massachusetts Department of Transportation Standard Specifications for Highways and Bridges unless otherwise specified herein.
- D. Substrates: Proceed with work only when substrate construction and penetrating work is complete and base is dry.
- E. Traffic Control: Maintain access for vehicular and pedestrian traffic and other construction activities.
- F. Grade Control: Establish and maintain required lines and elevations.

1.6 REGULATORY REQUIREMENTS

- A. Strictly comply with applicable codes, regulations and requirements of authorities having jurisdiction.

1.7 QUALITY ASSURANCE

- A. Bituminous concrete shall be prepared, mixed, transported, placed, compacted and finished in accordance with the requirements set forth in the latest edition of the "Standard Specifications for Highways and Bridges" (hereinafter referred to as "SSHB"), as published by the Massachusetts

Department of Transportation.

B. Tolerances

1. Establish and maintain grade control to required elevations and slope tolerances indicated on the Drawings. The maximum deviation in the finished surface planarity shall be 3/16 inch when measured in any direction with a 10 ft. straightedge.

- C. Laser-guided grading equipment shall be used for final grading of the gravel base to ensure conformance with specified tolerances

1.8 TESTING

- A. During the placing and rolling operation, repeated checks shall be made to ascertain the correct rate of application to provide the required compacted thickness
- B. If the average thickness is deficient from the specified thickness by one quarter (1/4) inch or more, the extent of the deficient area shall be corrected at the Contractor's expense.
- C. Upon completion of testing, the Contractor shall properly fill all test holes by compacting a fine aggregate bituminous concrete for the full depth of the core. The finished surface shall be smooth.

1.9 COORDINATION

- A. This Contractor shall coordinate with all other trades especially grading, curb installation, electrical and plumbing contractors, in order to prevent covering up unfinished or uninspected work. Any rework shall be done at no cost to the Owner.

1.10 LAYOUT AND GRADES

- A. A Registered Land Surveyor or Registered Professional Engineer employed by the Contractor shall lay out all lines and grade work in accordance with the Contract Documents.

1.11 DISTURBING EXISTING PAVEMENT DURING CONSTRUCTION

- A. Existing paved areas indicated on the drawings to remain shall be protected from damage by construction activities. Where sections of the finished paved areas have to be removed, all edges shall be saw cut and patched in accordance with this Section.
- B. Existing finished paved areas that require extensive cutting and patching or have become damaged and cannot be satisfactorily repaired by cutting and patching shall be resurfaced. Shape of these resurfaced areas shall be near and in rectangular patterns or shall conform to the shape or edges of other adjacent surface improvements. Edges of resurfaced areas shall be saw cut and existing pavements shall be removed from a distance of two feet into areas to be resurfaced, so that new pavement can neatly blend into existing pavement showing no joints or imperfections. If the gravel base course has been disturbed, the Contractor shall remove the disturbed material, repair the existing gravel base and apply a new binder course as specified herein.
- C. All paving beyond the project's property line shall be in accordance with the requirements of the authority having jurisdiction. Provide traffic control for any work within the Town's Right-of-Way.

PART 2 - PRODUCTS

2.1 ASPHALT PAVING MATERIALS AND PRODUCTS

- A. Course Aggregates: Provide clean, sound, angular crushed stone, crushed gravel, complying with ASTM D 692-88.
- B. Fine Aggregate: Provide sharp-edged natural sand or sand prepared from stone, gravel or combination thereof, complying with ASTM D 1073.
- C. Tack Coat: Asphalt tack coat shall be diluted asphalt emulsion SS-1.

2.2 ASPHALT PAVING MIXES

- A. Provide Class I asphalt aggregate mixture in compliance with Section 460, Paragraph 460.40, SSHB and as follows:
 - 1. Binder Course and Top Course: Provide Binder Course and Top Course conforming with the Job-Mix Formula given in Section M, paragraph M3.11.03, SSHB.
 - 2. The Binder Course shall consist of one lift of Binder Course asphalt paving to thickness as shown on the Contract Documents. The aggregate for the binder course shall conform to the following gradation requirements:

<u>SIEVE SIZE</u>	<u>PERCENT PASSING</u>
1"	100
3/4"	80 – 100
1/2"	55 - 75
#4	28 – 50
#8	20 - 38
#30	8 – 22
#50	5 - 15
#200	0 - 5
Bitumen % of mix	4.5 - 5.5

- 3. The Top Course for all asphalt, except for Tennis Courts, shall consist of one lift of Top Course asphalt paving to thickness as shown on the Contract Documents. The surface tolerance after completion shall be 1/8 inch when measured in any direction with a 10 ft. straightedge. The aggregate for the top course shall conform to the following gradation requirements:

<u>SIEVE SIZE</u>	<u>PERCENT PASSING</u>
5/8"	100
1/2"	95 – 100
3/8"	80 – 100
#4	50-76
#8	37-54
#30	17 - 29
#50	10 - 21
#200	2 - 7
Bitumen % of mix	5.5 – 7.0
A.C. 20 of 30	
Voids content less than 9%	

4. The Top Course for Tennis Courts shall be the compacted thickness indicated on the drawings consisting of one course of "Dense Mix" top course. The aggregate for the top course shall be 100 percent stone aggregate with no recycled asphalt paving (RAP) material. The stone aggregate conform to the following requirements.

SIEVE SIZE	PERCENT PASSING
1/2"	100
3/8"	80 - 100
#4	55 - 80
#8	48 - 63
#16	36 - 49
#30	24 - 38
#50	14 - 27
#100	6 - 18
#200	4 - 8
Bitumen % of mix	7.0 - 8.0

4.3 PAVEMENT MARKINGS

- A. Pavement-Marking Paint: Fast Drying White Water-borne White Traffic Paint and Fast Drying Yellow Water-borne Traffic Paint as specified in SSHB under Sections M7.01.23 and M7.01.24, respectively. Additional pavement-marking colors as shown on the drawings or details shall conform to the above.
1. Provide international symbol of accessibility at the designated accessible parking spaces. Color for accessible parking space lines and symbols shall be white. A blue painted square shall be painted at each symbol location prior to painting symbol.
 2. Stenciled pavement markings shall be installed on pavements as indicated on the Drawings to designate Fire Lanes, Reserved Parking, Fuel Efficient Vehicles, Electrical Vehicles, Bicycle Lanes or as determined by the Owner.
 5. Lines shall be true to alignment indicated on the Drawings. Stall lines shall be four inches wide with length and spacing as indicated on the Drawings.

2.4 BITUMINOUS MATERIALS

- A. Bituminous material for tack coat shall be one of the following:
1. Cut-back asphalt (rapid curing type) conforming to AASHTO M81, Grade RC-70 or
 2. Emulsified asphalt rapid-setting type conforming to AASHTO M140, Grade RS-1
- B. Bitumen shall be rapid setting type emulsified asphalt conforming to AASHTO M 140, Grade RS-1.
- C. Bituminous crack sealer shall be a hot-applied bituminous sealer conforming to Fed. Spec. SS-S-1401.

PART 3 - EXECUTION

3.1 GRADING AND COMPACTION OF SUB-BASE

- A. Subgrade preparation and base course materials and construction shall be performed as

specified in Section 312000 Earthwork and in accordance with geotech recommendations.

- B. Start of work under this Section shall constitute acceptance of the base conditions to which this work is to be applied. Any defects in work resulting from such conditions shall be corrected under this Section, at no additional cost to the Owner.

3.2 INSTALLATION OF ASPHALT PAVING

- A. Preinstallation examination Required: The Asphalt Paving Installer of asphalt paving shall examine the sub base and all related work, and the conditions under which this work is to be performed and notify the Contractor in writing of all deficiencies and conditions detrimental to the proper completion of their work. Beginning work means Installer accepts substrates, previous work and site conditions.
- B. Reference Standards: Install asphalt concrete in strict compliance with Sections 460.60 through 460.68 of the State Standard Specifications, except where more restrictive requirements are specified.
- C. Subbase Preparation: Do necessary grading in addition to that specified under Section 312000 Earthwork to bring sub-grade to required grades and sections for asphalt pavement base course construction. Tamp traces of trenches. Remove soft and otherwise unsuitable material and replace with approved material. Take every precaution to obtain a foundation of uniform bearing strengths. Any defects in this work shall be corrected under this Section at no additional cost to the Owner.
- D. Gravel Base Course Preparation: shall consist of approved gravel fill and placed on approved subgrade to the depth indicated on the Drawings and as specified under Section 312000 Earthwork The surface of the gravel base shall be shaped to the cross section of the pavement.
 - 1. The gradation shall conform to Gravel Borrow as specified in Section 312000 Earthwork. Gradation shall be determined by a mechanical wet sieve analysis and in accordance with ASTM D-422.
 - 2. The gravel shall be spread in layers from self-spreading vehicles or with power graders of approved types, or by hand methods upon the prepared subgrade. The gravel shall be compacted to not less than 95-percent of the maximum dry density of the material as determined by the Method of Test for ASTM Designation D - 1557, Method D. Grading and compaction shall continue until the surface is even and true to the proposed lines and grades within a tolerance of 3/8-inch above or below the required cross-sectional elevations and to a maximum irregularity not exceeding 3/8-inch under a ten foot line longitudinally. Any specific area which after being rolled, does not form a satisfactory, solid foundation shall be removed, replaced, and re-compacted. The gravel shall be spread and compacted in layers not exceeding 6-inches in compacted thickness. The Contractor shall furnish, set and maintain all line and grade stakes necessary to guide the automated grade control equipment.
 - 3. Contractor shall maintain base course in an acceptable condition, protected from traffic, erosion and other elements until the surface is placed.
 - 4. After the subgrade and /or existing pavement surfaces have been prepared as specified herein, the Contractor shall check all frames, covers, grates, water valve boxes and all miscellaneous castings that are located in the proposed pavement area to insure that all such items have been accurately positioned and set to the proper slope and elevation. All covers and grates shall be set flush with the required finished pavement surface. No depressions or mounds will be permitted in the pavement to accommodate inaccuracies in the setting of

these appurtenances.

5. For reclaimed base course requirements refer to Section 311000 – Site Preparation.
- E. Tack Coat: Tack coat shall be applied to previously paved, hardened surfaces. Apply uniformly by mechanical means at a rate of 0.05 gal/s.y. after thoroughly cleaning such surfaces of all foreign matter and loose material. Surfaces shall be dry before the tack coat is placed. The tack coat shall be applied immediately prior to laying the new pavement.
- F. Placing Mix: Paving shall be laid in two courses except as noted on the Drawings. The thickness of each course shall be as shown on the Drawings and measured in place after compaction. The first course shall be the Binder Course and the second course shall be Top Course as defined in "Table A" of Section M3.11.03 "Job-Mix Formula" of the SSHB. A minimum of two weeks (14-days) shall pass between the installation of the binder course and top course.
 1. Refer to Section 321823.39 Resilient Sport Surfacing (running track) for additional requirements pertaining to asphalt pavements at the running track.
 2. Refer to Section 321823.43 Recreational Court Surfacing (tennis courts) for additional requirements pertaining to asphalt pavements at the tennis Courts.
 3. Any unsatisfactory irregularities or defects remaining after the final compaction shall be corrected by removing and replacing with new material as specified, to form a true and even surface, All minor surface projections, joints and minor honeycombed surfaces shall be ironed out smoothly to grade, as directed.
 4. No vehicular traffic or loads shall be permitted on the newly completed pavement until stability has been attained and the material has cooled sufficiently to prevent distortion or loss of fines.
- G. Bituminous Concrete Curb: The bituminous concrete mixture shall be machine formed by a self-powered curbing machine capable of extruding and compacting the mixture, free of honeycombs. The berms shall be installed on the Binder Course prior to the installation of the Top Course.
 1. Bituminous concrete curb shall conform to Section 501.64 of the "Standard Specifications" for Class 1 Bituminous Concrete Curb and shall meet the dimensions as shown on the Contract Documents.
 2. Bituminous concrete shall meet the requirements of Dense Mix, "Standard Specifications" Section M3.12.00.
- H. Rolling: Begin rolling mixture when asphalt concrete can bear weight of roller without excessive displacement. Roll at least three times and provide a smooth, compact, uniform surface free of roller marks. After first rolling repair displaced area as needed with additional hot material. Roll at least two additional times to thoroughly compact concrete to maximum density and to remove roller marks.
- I. Tolerances: The finished surface of each hot-mixed asphalt course shall be tested for smoothness using a 10-foot straight edge applied parallel with and at right angles to the center line of the paved area. Surfaces exceeding the following tolerances within the 10-feet will not be accepted.

Binder Course: 1/4-inch

Top Course: 3/16-inch

3.3 PATCHING EXISTING ASPHALT PAVEMENT

- A. In areas on site where new pavement abuts existing pavement and/or where existing pavement requires patching due to removal of existing pavement for installation of work under this Contract,

patching of existing pavement shall be as follows:

1. Sawcut the existing edge of pavement in a straight line at a 90-degree angle to the vertical in such a manner that all existing loose or cracked areas of pavement are removed.
 1. Edges of existing pavement shall be painted with a thin coat of bitumen (RS-1) immediately before placing new pavement.
 2. Any joints at junctions of old and new pavements shall be sealed with a hot poured rubber asphalt sealer and covered with sand.
 4. Asphalt shall be installed as specified herein. Smooth transition surfaces shall be provided where new pavement abuts existing paved surfaces.
- B. All asphalt patching work within public right-of-way's shall be completed in accordance with the requirements of the authority having jurisdiction.
1. Provide traffic control for work within the public right-of-way.
 2. All road surfaces shall be saw cut before any excavation to prevent damage to pavement to remain.
 3. Excavation shall be completed in a safe and workmanlike manner and shall minimize obstruction of pedestrian and vehicular traffic.
 4. Gravel Borrow shall be used for base course construction and placed in six-inch lifts compacted to 95% of the maximum dry density by mechanical means.
 5. Resurfacing:
 - a. The work to be completed hereunder shall include the replacement of all existing bituminous pavements disturbed by the work. This shall include roadways, sidewalks, berms, driveways, parking lots and other paved areas encountered in the work.

Resurfacing will not be strictly limited to those areas disturbed, when in the judgment of the Architect an expansion of the work is necessary for proper restoration and to those areas specifically shown on the Drawings.
 - b. All work shall conform the requirements of the Massachusetts Highway Department SSHB, latest edition.
 - c. All cut joints at existing and new top pavement surfaces shall be sealed with bitumen and sand. This includes roadways, sidewalks, driveways, and all other pavements.

3.4 PAVEMENT MARKINGS

- A. Work under this item shall be in conformance with Section 860 of the Standard Specifications and the Manual on Uniform Traffic Control Devices, current edition.
- B. Provide painted parking stripes and other pavement markings, as indicated on the drawings. Apply paint with mechanical methods and templates to ensure uniform, straight lines and even line widths. Clean surface to totally eliminate all loose material and dust. Apply paint in strict compliance with manufacturer's instructions and recommendations. Allow for proper curing of substrates before application of paints. Apply number of coats and dry film thickness as

recommended by paint manufacturer.

- C. Pavement markings shall be reapplied during the one-year guarantee period specified herein if the markings exhibit wear under normal use.

3.5 CLEANING, REPAIR AND PROTECTION

- A. Three days after rolling, the finished pavement shall be tested. Any section that shows ponding, indentation, rutting or picking up shall be resurfaced at the Contractor's expense.
- B. Provide temporary protection to ensure work is completed without dirt, stains, damage or deterioration at time of final acceptance. Clean up stains and spills as they occur. Remove protection and clean as necessary immediately before final acceptance review.

3.6 GUARANTEE

- A. The Contractor shall guarantee all pavement and pavement marking installations, including materials and workmanship, for a period of one year from the date of acceptance. The Contractor shall make interim repairs as necessary to maintain all paved areas in good, usable conditions.

END OF SECTION

SECTION 32 13 13
EXTERIOR CONCRETE

PART 1 - GENERAL

1.06 GENERAL REQUIREMENTS

- C. The conditions of the Contract, including Division 00 and Division 01, apply to the work under this Section.
- D. The Contractor shall prior to any removal of surplus fill, excavated material, or debris from the site, furnish written evidence satisfactory to the owner or owner's representative that he has an approved dumping location for debris and/or spoil from his/her excavation activities.

1.07 WORK INCLUDED

- C. The work of this Section consists of providing all labor, equipment, materials, incidental work, and construction methods necessary to furnish and install reinforced concrete pavement, stairs and walls as indicated on the Contract Documents and as specified herein.
 - 1. Concrete footings for site improvements
 - 2. Concrete paving for pedestrian and vehicular applications
 - 3. Accessible curb ramp including detectable warnings
 - 4. Concrete stairs
 - 5. Controlled Permeability Formliner
- D. Examine all other Sections of the Specifications and all Drawings for the relationship of the work under this Section and the work of other trades. Cooperate with all trades and all departments within jurisdiction and coordinate all work under this Section.
- E. Other specification sections that directly relate to the work of this Section include, but are not limited to, the following:
 - 1. Division 26 – Electrical
 - 2. Section 023000 – Subsurface Investigation
 - 3. Section 024100 – Demolition
 - 4. Section 033000 – Cast-In-Place Concrete
 - 5. Section 055000 – Metal Fabrications
 - 6. Section 129300 – Site Furnishings
 - 7. Section 312000 – Earthwork
 - 8. Section 312500 – Erosion and Sedimentation Controls
 - 9. Section 321216 – Asphalt Paving
 - 10. Section 321400 – Unit Pavers
 - 11. Section 321600 – Curbing
 - 12. Section 323000 – Site Improvements
 - 13. Section 323100 – Fencing
 - 14. Section 32 91 00 – Loam and Planting Preparation
 - 15. Section 33 05 05 – Selective Site Utility Demolition
 - 16. Section 33 10 00 – Water Utilities
 - 17. Section 33 30 00 – Sanitary Sewerage Utilities
 - 18. Section 33 40 00 – Storm Drainage Utilities

F. The following items shown on the Drawings and/or noted herein shall be furnished and installed under their Sections of the Specifications:

1. Concrete for concrete footings included herein
2. Materials for grading and compacting subbase under 312000 Earthwork

G. Sustainable Building Requirements:

1. The Contractor is to implement practices and procedures to meet the project's sustainable performance goals, which include achieving LEED v4 Silver certification based on USGBC's "LEED Version 4 for Building Design and Construction: Schools" (LEED v4 BD+C: Schools).
2. The work of this Section includes responding to Architect or Contractor requests for additional information or product data and may be required following initial Green Building Certification Institute (GBCI) review of LEED Application.
3. Product substitution requests are subject to additional LEED submittal requirements including, but not limited to, Environmental Product Declarations (EPD), Health Product Declarations (HPD), and General Emissions Testing.

1.08 SUBMITTALS

A. Submit manufacturer's product data for the following:

1. Concrete design mix 5,000 PSI for all exposed or above grade concrete placements.
2. Concrete design mix 4,000 PSI for all below grade concrete placements and footings.
3. Preformed joint filler
4. Joint sealant
5. Detectable Warnings
6. Welded wire mesh and expansion joint dowels
7. Concrete curing compound and admixtures
8. Supports and accessories (form ties, spreaders.) for reinforcement.
9. Penetrating concrete sealer.

B. Construct Concrete Mock Up Sample Panels:

1. Samples shall not be constructed in an area of proposed finish work. Samples shall be constructed within the vicinity of the proposed finish work to facilitate comparisons during construction. The samples shall demonstrate the typical installation of concrete, including score lines, expansion joint and sealant, curing and finishing material, surface texture, color, and edge treatment.
2. The accepted samples, upon approval, shall be maintained as the minimum standard of quality for approval of each type of new concrete pavement work required for the project. If the original sample panel is not approved, the Contractor shall provide additional sample panels, at no additional cost to the Owner until a mock up sample is approved. Unacceptable sample panels shall immediately be removed from the site.
3. All sample panels shall be completed 28 days prior to review to allow for sufficient curing and color stabilization.

4. The following concrete paving mock up samples shall be provided:

- 1) Standard gray concrete walk: 6'x6' sample panel including expansion and score joint.
- 2) Concrete for Vertical surfaces, Wall Mockup shall be a 24" height x 12" wide x 36" length and include scoring and any finishing requirements.

1.09 LAWS, ORDINANCES, PERMITS AND FEES

A. The Contractor shall:

1. Give necessary notices, obtain all permits and pay all governmental taxes, fees and other costs in connection with this work, file all necessary plans, prepare documents and obtain all necessary approvals.
2. Obtain all required certificates of inspection for this work and deliver same to the Architect before request for acceptance and final payment for the work.
3. All concrete walks shall conform to the applicable regulations of the Massachusetts Architectural Access Board and the Americans with Disabilities Act.
4. Include in the work, without extra cost to the Owner, any labor, materials, services, apparatus, drawings (in addition to contract drawings and documents) in order to comply with all applicable laws, ordinances, rules and regulations in Wakefield and the Commonwealth of Massachusetts, whether or not shown on the Drawings and/or specified.

1.10 DEFINITIONS

A. The following related items are included herein and shall mean:

1. S.S.H.B. - Standard Specifications for Highways and Bridges, the Commonwealth of Massachusetts, Department of Transportation, latest edition.
2. A.S.T.M. - American Society for Testing and Materials.
3. A.A.S.H.T.O. - American Association of State Highway and Transportation Officials.

1.11 SUBSURFACE INFORMATION

A. The Owner assumes no responsibility for the Contractor's failure to make his own site investigation and makes no representation regarding the character of the soil or subsurface conditions which may be encountered during the performance of the work.

1.12 FINISHED GRADES

A. The words "finished grades" as used herein mean the required final grade elevations indicated on the Drawings. Where not otherwise indicated, site areas shall be given uniform slopes between points, for which finished grades are shown, or between such points and existing grade except that vertical curves or roundings shall be provided at abrupt changes in slope.

1.13 GRADES AND ELEVATIONS

A. The Drawings indicate, in general, the alignment and finished grade elevations. The Landscape

Architect, however, may make adjustments in grades and alignment as are found to avoid interference and to adapt the grading to special conditions encountered.

1.14 WORK IN THE PUBLIC WAYS

- A. Notify the appropriate municipal officials at least seven calendar days in advance of commencing any work in the public ways to obtain all required permission to perform this work. Perform all work in the public ways in a manner required by the municipal authorities.
- B. Should there be any conflict between requirements specified in the Contract Documents and those of the municipality, the municipal requirements shall govern.
- C. Do not close or obstruct any streets or sidewalks unless and until they have been discontinued by the appropriate municipal authority or unless and until he shall have first secured all necessary or other permits therefor. No materials whatsoever shall be placed or stored in the streets. Conduct all operations to interfere as little as possible with the use ordinarily made of roads, driveways, sidewalks, or other facilities near enough to the work to be affected thereby.

1.15 QUALITY ASSURANCES

- A. Unless otherwise specified, work and materials for construction of the reinforced Portland cement concrete paving shall conform to ACI 316R, and applicable portions of the following:
- B. MassDOT Specifications Section 476 Cement Concrete Pavement
- C. Surfaces of curb ramps and handicapped access ramps shall be stable, firm and slip resistant. Construct ramps so that water does not accumulate on pavement surfaces adjacent to the ramp.
- D. Paving work and base course installation, shall be done only after excavation and construction work which might damage them have been completed. Damage caused during construction shall be repaired before acceptance.
- E. Existing paving areas shall, if damaged or removed during course of this project, be repaired or replaced under this Section. Workmanship and materials for such repair and replacement, except as otherwise noted, shall match as closely as possible those employed in existing work installed under this Contract.
- F. Pavement, base, or subbase shall not be placed on a muddy or frozen subgrade.

PART 2 - PRODUCTS

2.01 AGGREGATE BASE COURSE

- A. Base course shall be specified, provided, installed and paid for under EARTHWORK Specification Section.

2.02 FORM MATERIALS

- A. Unless otherwise indicated, construct form work for concrete surfaces with plywood, metal, metal framed plywood faced or other acceptable panel-type materials, to provide continuous, straight, smooth, exposed surfaces. Formwork for all exposed vertical surfaces shall be lined using a Controlled Permeability Formliner (CPF). Furnish in largest practical sizes to minimize number of joints and to conform to the joint system shown on Drawings. Provide form material with

sufficient thickness to withstand pressure of newly placed concrete without bow or deflection.

- B. Controlled Permeability Formliner (CPF) shall be a two-layer non-woven polypropylene fabric that provides a drainage layer allowing surplus water and air to drain from the surface of freshly poured concrete and a filter layer to retain cement particles. CPF shall modify the surface characteristics of the concrete producing an even surface texture with minimal bug holes and other surface imperfections. Formliner shall be Formtex CPF Liner as manufactured by Fibertex Nonwovens LLC (815) 349-3200, salesusa@fibertex.com. Randy Blasczyk 815-349-3204

1. Additional approved products are:

- 1) Zemdrain as provide by Max Frank www.maxfrank.com
DuPont Zemdrain as provided by Newkem www.newkem.com
- 2) or approved equal.

- C. Use plywood complying with U.S. Product Standard PS-1 "B-B (Concrete Form) Plywood," Class I, Exterior Grade or better, mill-oiled and edge-sealed, with each piece bearing legible inspection trademark.

- D. Concrete form ties shall be snap-ties with 1½" breakback minimum, snap-ties shall have associated cone form allowing grout coverage for form tie after formwork removal.

2.03 REINFORCING MATERIALS

- A. Reinforcing Bars: Epoxy coated steel meeting ASTM A775, Grade 60.

- B. Welded Wire Fabric (WWF): ASTM A185, epoxy coated welded steel wire fabric. Fabric reinforcement shall be furnished in flat sheets.

1. Provide 6 inches x 6 inches W1.4 x W1.4 WWM for 4 inch thick concrete pavement.
2. Provided 6 inches x 6 inches W2.9 x W2.9 WWM for 6 inch thick concrete pavement.
3. Welded wire fabric support chairs shall be 3" plastic supports that flex during concrete pours and gradually restore to original shape. Support chairs shall be Mesh-Ups distributed by www.globalindustrial.com 888-978-7759, or Architect approved equal.

- C. Supports for Reinforcement: Provide supports for reinforcement including bolsters, spacers and other devices for spacing, supporting and fastening reinforcing bars and welded wire fabric in place. Use wire bar type supports complying with CRSI recommendations.

- D. Steel expansion dowels shall be hot-rolled plain steel rounds conforming to the requirements of AASHTO M31, Grade 60 and consisting of a one-half inch #5 smooth dowel reference Detail L05-00 Expansion Joint TYP. #5 rebar width = 5/8" nom. dia. by twenty-four inches (1/2"x24") smooth steel dowel and compatible waxed tube sleeve, twelve inches (12") in length. Dowels and sleeves shall be as furnished by A.H. Harris & Sons, Inc., by U.S. Steel Corp., by Edgcombe Steel Corp., or approved equal. Dowels shall be epoxy coated.

2.04 EXPANSION JOINT FILLER

- A. Expansion joint filler shall be closed cell polymer foam meeting requirements of ASTM D1752, Sections 3.1 to 3.4, based on compression requirement of 10 psi minimum and 25 psi maximum.

Recovery rate following 50-percent compression shall exceed 99-percent recovery, per ASTM D545. Foam shall be Ceramar foam filler manufactured by W.R. Meadows Co. or an approved equal. Joint sealant shall color match concrete refer to section 03300 for joint sealant requirements.

- B. Expansion joint filler shall have a removable cap cover for the joint filler with integral permanent plastic bond breaker such as Snap-Cap from Seal Tight manufactured by W.R. Meadows, Inc., or approved equal. Cover width shall be sized to match width of joint filler.
- C. Expansion Dowels: refer to Reinforcing Materials in this Section.

2.05 JOINT SEALANT

- A. Joint sealant and primer shall be polyurethane-based, one component, elastomeric sealants, complying with Fed. Spec. TT-S-00230C, Class A Type 1. Color shall be as selected by the Architect. Sealants shall be self-leveling pour grade type.
 - 1. Vulkem 45, as manufactured by Mameko International, 4475 East 175th Street, Cleveland Ohio 44182, (800) 321-6412.
 - 2. Urexpan NR-210, as manufactured by Pecora Corporation, 165 Wambold Road, Harleysville, PA 10348, (215) 723-6051.
 - 3. PSI 952, as manufactured by Polymeric Systems Inc., Phoenixville, PA, (800) 228-5548.
- B. Provide only materials which are known to be fully compatible with the actual installation condition, as shown by the manufacturer's published data or certification. Use manufacturer's recommended joint primer.

2.06 PORTLAND CEMENT CONCRETE

- A. Cast-in-place concrete shall be air-entrained concrete with a minimum 28-day compressive strength as identified below. Thickness of concrete shall be as noted on the Contract Documents.
- B. Site Concrete including Walls, Curbs, and Site Retaining Walls (all concrete exposed to weather): Proportion structural normal weight concrete mixture as follows:
 - 1) Minimum Compressive Strength: 5,000 PSI at 28 days.
 - 2) Maximum water – cementitious material ratio: 0.40.
 - 3) Slump Limit: 4-in., plus or minus 1-in.
 - 4) Air Content: 6 percent, plus or minus 1 1/2 percent at point of delivery.
 - 1. 3/4-in. nominal maximum aggregate size.
- C. Exterior Paving Concrete: Proportion structural normal weight concrete mixture as follows:

- 1) Minimum Compressive Strength: 5000 PSI at 28 days.
- 2) Maximum water – cementitious material ratio: 0.40.
- 3) Slump Limit: 4-in., plus or minus 1-in.
- 4) Air Content: 6 percent, plus or minus 1 1/2 percent at point of delivery.
2. 3/4-in. nominal maximum aggregate size.

D. Site Concrete footings and foundations (below grade placements):

- 1) Minimum Compressive Strength: 4000 PSI at 28 days.
- 2) Maximum water – cementitious material ratio: 0.40.
- 3) Slump Limit: 4-in., plus or minus 1-in.
- 4) Air Content: 6 percent, plus or minus 1 1/2 percent at point of delivery.
- 5) 3/4-in. nominal maximum aggregate size.

- E. Cement shall be stored in a weather-tight structure and in such a manner as to prevent deterioration or intrusion of foreign matter. It shall be easily accessible for proper inspection and identification of each shipment. Cement that has hardened or partially set shall not be used.

2.07 CURING COMPOUND FOR UNCOLORED CONCRETE PAVING

- A. All curing compounds shall conform to requirements of ASTM Designation C-309, Type I, clear and C-156. No materials containing wax or saponifiable materials will be permitted.
- B. Curing compound shall be Master Builders "Master Seal", Symons "Cure and Seal", Sonneborn "Kure-N-Seal", "CS-309" by W.R. Meadows or equal, conforming to ASTM 309, Type 1 and 2.

2.08 PENETRATING CLEAR SEALER

- A. Penetrating clear sealer for exterior concrete shall be "MasterProtect H 1000" Penetrating Clear Sealer as manufactured by BASF, or approved equal from Euclid Chemical or Sika Corporation. Clear breathable, high-performance, 100 percent silane, water repellent sealer for protecting horizontal and vertical concrete surfaces. Penetrates deeply, sealing out water, chloride ions, and acids, preventing damage from freeze/thaw cycles
- B. Provide 5-year labor and materials warranty.

2.09 DETECTABLE WARNINGS

- A. Shall be replaceable tactile/detectable warning surface tiles for cast in place concrete meeting or exceeding all ADA and MAAB requirements for tactile warning surfaces. Tiles shall be manufactured using a matte finish exterior grade homogeneous (uniform color throughout thickness of product) glass and carbon reinforced polyester based composite material. Truncated domes must contain fiberglass reinforcement within the truncated dome for superior structural integrity and impact resistance. Tiles shall feature a minimum of eight (8) embedded corrosion resistant concrete inserts with 1/2" x 1 1/2" heavy duty steel bolts and washers. Bolts shall be covered with a structural water tight cap.
- B. The basis of quality, design and function required is based on ADA Solutions Inc. of Chelmsford, MA 800-372-0519, www.adatile.com, info@adatile.com.

C. Approved products and sources:

1. Durateck heavy duty 1/2 inch thick replaceable detectable warnings from Detectile Corporation, Oak Brook, IL (630) 734-0277,
2. Armor Tile Replaceable Herculite Series from Armor Tile, Williamsville, NY, Tel: 800 682-2525,

D. Submit product data demonstrating conformance with the specifications and drawings.

E. Properties: polymer-composite tiles minimum 25,000 PSI compressive strength, 11,000 PSI tensile strength, 29,000 PSI Flexural Strength, coefficient of friction 0.80 when wet.

F. Raised Truncated Domes shall be a square grid pattern of raised truncated domes of 0.2" nominal height, base diameter of 0.9" and top diameter of 0.45". The Federal Code of Regulations permits a truncated dome spacing range of 1.6"-2.4." For superior wheelchair, walker and shopping cart mobility, the preferred truncated dome spacing shall have a center-to-center (horizontally and vertically) spacing of 2.35", measured between the most adjacent domes on square grid.

G. Color: Shall be uniform integral color and shall meet or exceed the ADA recommended guideline of 70% contrast in light reflectance between detectable warning and adjoining surface. Color to be approved by Architect prior to ordering materials.

H. Warranty: Shall be 5 year warranty to include replacement due to breakage or deformation of tactile warning surface material.

PART 3 - EXECUTION

3.01 PREPARATION OF SUBGRADE

- A. Areas to be paved shall be compacted and brought to subgrade elevation and all work specified, performed and paid under EARTHWORK Specification Section. Prepared subgrade will be inspected by the Owner's Representative. Contractor shall arrange to have the Owner's Representative visit the site to inspect and approve subgrade.

3.02 AGGREGATE BASE COURSE

- A. Base course shall conform to ASTM C33
- B. Base course shall be specified, provided, installed and paid for under EARTHWORK Specification Section.

3.03 ERECTION OF FORMWORK

- A. Forms shall conform to the lines, dimensions and shapes of concrete shown providing for openings, recesses, keys, slots, beam pockets and projections.
- B. Make forms clean and free of foreign material before placing concrete.
- C. Do not use earth cuts as forms for vertical surfaces, unless approved by the Architect.
- D. Design of Formwork:

1. Comply with ACI 301, Chapter 4, Paragraph 4.2. Formwork drawings shall bear the seal of licensed professional engineer.
2. Form rods and tie wires of exterior surfaces shall slope down from the inside to outside of forms.
3. Provide forms so that no discernible imperfection is in evidence in finished concrete surfaces due to deformation, bulging, jointing, or leakage of forms.

3.04 PLACING OF REINFORCEMENT MATERIAL

- A. Reinforcement shall be placed in accordance with requirements of CRSI Standards "Placing Reinforcing Bars" and with further requirements below.
- B. Steel reinforcing shall be thoroughly cleaned of all foreign material which may reduce the bond between the concrete and reinforcing.
- C. Welded wire mesh shall be placed midway within the depth, and parallel to the finished concrete pavement surface. Do not pour concrete over top of reinforcement unless it is supported underneath. Where mesh reinforcement is spliced, it shall be lapped at least 12 inches.
- D. Reinforcing steel anchors shall be securely wired in the exact position called for, and shall be maintained in that position until concrete is placed.
- E. Unless otherwise indicated on the Contract Documents, reinforcing shall extend within 2 inches of formwork and expansion joints.

3.05 EXPANSION JOINTS

- A. Expansion joints shall be as located on the Contract Documents. Expansion joint shall be formed in the concrete to required width with preformed joint filler in place. Joint filler shall extend the full depth of the slab.
- B. For concrete pavements, depth of joint filler shall installed to form a 3/4 -inch deep sealant recess below finished concrete surface.
- C. Provide expansion joints as indicated on the Contract Documents. Unless otherwise indicated on the Contract Documents, expansion joints shall be located at 30 feet on-center, maximum.
- D. Expansion joints shall be placed where pavement meets flush foundations and footings, concrete vertical curb or other vertical structures, including light bases, hydrants, walls, buildings, piers and walls, and at other conditions as shown on the Contract Documents.
- E. Contractor shall request the presence of the Owner's Representative to review the layout of expansion joints prior to pouring the concrete.
 1. Follow the manufacturer's application recommendations for joint filler and sealant.
 2. Joint alignment shall be straight and true.
- F. Where the expansion dowel system is used in the expansion joints, steel plates and pocket former sleeves shall be set parallel with the top and bottom surfaces of the concrete slab and installed according to the manufacturer's installation instructions.

3.06 PLACING OF PORTLAND CEMENT CONCRETE

A. Proportioning and Design of Mixes

1. Prepare design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in ACI 301. If trial batch method used, use an independent testing facility acceptable to Architect for preparing and reporting proposed mix designs. The testing facility shall not be the same as used for field quality control testing unless otherwise acceptable to Architect.
2. Submit written reports to Architect of each proposed mix for each class of concrete at least 15 days prior to start of work. Do not begin concrete production until mixes have been reviewed by the Landscape Architect.
3. Adjustments to Concrete Mixes: Mix design adjustments may be requested by Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant; at no additional cost to Owner and as accepted by Architect. Laboratory test data for revised mix design and strength results must be submitted to and accepted by Architect before using in work

B. Ready Mix Concrete

1. Comply with ASTM C94.
2. Add mixing water only at the site.
3. Discharge the concrete completely at the site within 1-1/2 hours after the introduction of the cement to the aggregates. In hot weather reduce this time limit so that no stiffening of the concrete shall occur until after it has been placed.
4. Begin the mixing operation within thirty minutes after the cement has been intermingled with the aggregates.

C. Placing Concrete

1. Remove water and foreign matter from forms and excavations and, except in freezing weather or as otherwise directed, thoroughly wet wood forms just prior to placing concrete. Place no concrete on frozen soil and provide adequate protection against frost action during freezing weather
2. Soil bottom for slabs and footings, reinforcing, inserts, and forms shall be reviewed by Architect or their appointee before placing concrete.
3. To secure full bond at construction joints, surfaces of concrete already placed, including vertical and inclined surfaces, shall be thoroughly cleaned of foreign materials and laitance, roughened with suitable tools such as chipping hammers or wire brushed, and re-cleaned by stream of water or compressed air. Well before new concrete is deposited, joints shall be saturated with water. After free or glistening water disappears, joints shall be given thorough coating of neat cement slurry mixed to consistency of very heavy paste. Surface shall receive coating of at least 1/8 inch thick; this shall be scrubbed in by means of stiff bristly brushes. New concrete shall be deposited before neat cement dries.
4. Do not place concrete having a slump outside of allowable slump range.

5. Transport concrete from mixer to place of final deposit as rapidly as practical by methods that prevent separation of ingredients and displacement of reinforcement and that void rehandling. Deposit no partially hardened concrete. When concrete is conveyed by chutes, equipment shall be of such size and U-shaped design as to insure continuous flow in chute. Flat (coat) chutes shall not be employed.
6. During and immediately after depositing, concrete shall be thoroughly compacted by means of internal type mechanical vibrators or other tools, spading to produce required quality of finish.
7. Vertical lifts shall not exceed 18 inches. Vibrate through successive lifts to avoid pour lines. Vibrate first lift thoroughly until top of lift glistens to avoid stone packets, honeycomb and segregation.
8. Concrete shall be deposited continuously and in layers of such thickness that no concrete will be deposited on concrete that has hardened sufficiently to cause formation of seams and planes of weakness within section. If section cannot be placed continuously between planned construction joints, as specified, field joint and additional reinforcement shall be introduced so as to preserve structural continuity. Architect shall be notified in any such case.

D. Form Removal

1. Do not remove forms until the concrete has thoroughly hardened and has attained sufficient strength to support its own weight and construction live loads to be placed thereon, without damage to the structure. In general, do not disturb forms for framing until the concrete has attained at least 40% of design strength for side forms and 80% of design strength for bottom forms. Remove no forms for 24 hours after placing concrete. Protect concrete walks from pedestrian traffic for a period of 3 days after placing. Damp cure as per standards above. Be responsible for proper form removal and replace any work damage due to inadequate maintenance or improper or premature form removal.
2. Where use of metal form ties extending to within less than 1-1/2 in. of the face of permanently exposed concrete has been unavoidable, cut off such ties at least 1-1/2 in. deep in the concrete but not less than 72 hours after concrete has been cast. Remove forms by methods which will not spall the concrete or cause any injury whatsoever. Hammering or prying against concrete will not be permitted.

3.07 CURING CONCRETE

- A. It is essential that concrete be kept continuously damp from time of placement until end of specified curing period. It is equally essential that water not be added to surface during floating and troweling operations, and not earlier than 24 hours after concrete placement. Between finishing operations surface shall be protected from rapid drying by a covering of waterproofing paper. Surface shall be damp when the covering is placed over it, and shall be kept damp by means of a fog spray of water, applied as often as necessary to prevent drying, but not sooner than 24 hours after placing concrete. None of the water so applied shall be troweled or floated into surface.
- B. Standard gray concrete surfaces shall be cured by completely covering with curing paper or application of a curing compound.
- C. Concrete cured using waterproof paper shall be completely covered with paper with seams lapped and sealed with tape. Concrete surface shall not be allowed to become moistened between 24 and 36 hours after placing concrete. During curing period surface shall be checked frequently, and sprayed with water as often as necessary to prevent drying, but not earlier than

24 hours after placing concrete.

- D. If concrete is cured with a curing compound, compound shall be applied at a rate of 200 square feet per gallon, in two applications perpendicular to each other.
- E. Curing period shall be fourteen days minimum.

3.08 DETECTABLE WARNINGS

- A. Contractor shall not install Tactile Warning Surface Tiles until all submittals have been reviewed and approved by the Architect.
- B. Tile shall be installed per manufacturer's instructions and in accordance with the Drawings.
- C. To the maximum extent possible, the Tiles shall be oriented such that the rows of in-line truncated domes are parallel with the direction of the ramp. When multiple Tiles regardless of size are used, the truncated domes shall be aligned between the tactile warning surface tiles and throughout the entire tactile warning surface installation.
- D. In accordance with the Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Rights of Way (7/23/11, US Access Board): Sections 304 + 305), Tactile Warning Surface Tile shall be located relative to the curb line as shown within Sections 304+305 of the Guidelines.
- E. Tiles shall be tamped or vibrated into the fresh concrete to ensure that there are no voids or air pockets, and the field level of the Tactile Warning Surface Tile is flush to the adjacent concrete surface or as the Drawings indicate to permit proper water drainage and eliminate tripping hazards between adjacent finishes.
- F. On Continuous Runs: The Installer shall leave a 1/8" nominal gap between successive Tactile Warning Surface Tiles. As part of the concrete finishing operation, the Installer shall apply 1/4" edge treatment around the perimeter of the Tactile Warning Surface Tiles to facilitate future replacement of the Tactile Warning Surface Tile. A Urethane Sealant such as Sikaflex 1a or BASF NP1 shall be applied to the edge treatment for a watertight Tactile Warning Surface Tile installation.
- G. Custom field cut each panel where required to accommodate adjacent site improvements, furnishings or along a radial edge. Field cuts shall not leave partial truncated domes.

3.09 FIELD QUALITY CONTROL

- A. Sampling and testing for quality control during placement of concrete may include the following, as directed by the Landscape Architect.
- B. Sampling Fresh Concrete: ASTM C172, except modified for slump to comply with ASTM C94.
- C. Slump: ASTM C143, one test for each concrete load at point of discharge; and one test for each set of compressive strength test specimens.
- D. Air Content: ASTM C173, volumetric method for lightweight or normal weight concrete; one for each set of compressive strength test specimens.
- E. Concrete Temperature: Test hourly when air temperature is 40 deg. F (4 deg. C) and below, and when 80 deg. F (27 deg. C) and above; and each time a set of compression test specimens

made.

- F. Compression Test Specimen: ASTM C31; one set of 6 standard cylinders for each compressive strength test, unless otherwise directed. Mold and store cylinders for laboratory cured test specimens except when field-cure test specimens are required.
- G. Compressive Strength Tests: ASTM C39; one set for each 100 cu. yds. or fraction thereof, of each concrete class placed in any one day or for each 5,000 sq. ft. of surface area placed; 1 specimen tested at 7 days, 2 specimens tested at 28 days, and one specimen retained in reserve for later testing if required.
- H. When strength of field-cured cylinders is less than 85% of companion laboratory-cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing the in-place concrete.
- I. Strength level of concrete will be considered satisfactory if average of sets of three consecutive strength test results equal or exceed specified compressive strength, and no individual strength test result falls below specified compressive by more than 500 psi.
- J. Test results will be reported in writing to Landscape Architect and Contractor on same day that tests are made. Reports of compressive strength tests shall contain the project identification name and number, date of concrete placement, name of concrete testing service, concrete type and class, location of concrete batch in structure, design compressive strength at 28 days, concrete mix proportions and materials; compressive breaking strength and type of break for both 7-day tests and 28-day test.
- K. Additional Tests: The testing service may make additional tests of in-place concrete when test results indicate specified concrete strengths and other characteristics have not been attained in the structure. Testing service may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C42, or by other methods as directed. Contractor shall pay for such tests conducted, and any other additional testing as may be required, when unacceptable concrete is verified.

3.10 FINISHING

- A. General Requirements for Flatwork: Strike off top surfaces of finished fill and monolithic slabs true and level within a tolerance of 1/8 in. in 10 ft. and measured with a 10 ft. straightedge placed in any direction at any location. Set edge forms and intermediate screed strips accurately and sufficiently rigid to support screeds and so that proper surface elevations and concrete thickness are achieved allowing for dead load deflection and camber of formwork. Take measurements and control tolerances by the use of transit instrument. Upon completion of leveling, remove screed and fill spaces with concrete. Concrete shall have a medium broom finish of parallel marks. Brooming shall be at right angles to the axis of walk or as shown on the Drawings. Concrete surfaces for sub-base at unit pavement shall be woodfloated with a slightly rough surface, and finished true to line and grade per the Contract Documents.
- B. Concrete for cast-in-place walls, seating, benches and stairs shall have a smooth formliner finish. Vertical concrete without the controlled permeability formliner finish shall be rejected. Top horizontal surface shall be steel trowelled smooth, top and vertical edge shall be chamfered and vertical exposed surfaces shall be rubbed with a carborundum stone to provide a hand smooth surface. Finished surface to be approved by Landscape Architect.
- C. Control Joints in concrete paving, walls and stairs shall be saw cut joints, sawn by using a diamond blade concrete power saw. To prevent random cracking, control joints shall be cut as

soon as the concrete is hard enough that the edges abutting the cut do not chip from the saw blade. Sawn joints shall be true to layout indicated in the Contract Drawings.

1. Control joint depth shall be a minimum 25 percent of slab depth or $\frac{3}{4}$ " in walls.
2. At walls and stairs, where sawn joints are shown on the drawings, they shall continue on both exposed horizontal and vertical surfaces down to finish grade.

3.11 APPLICATION OF PENETRATING SEALER

- A. Apply 2 coats of the approved penetrating sealer to all exterior cast in place concrete including paving, stairs and walls between 28 to 42 days after installation in accordance with the manufacturer's recommendations. All surfaces exposed above finish grade shall be uniformly coated.
- B. Sealer application shall be performed in the presence of the Owner's Representative.
- C. Sealed surfaces shall be protected from rain for a minimum of 12 hours. Access to sealed surfaces shall be prohibited with effective barriers until surfaces are completely dry.

3.12 PROTECTION OF CONCRETE SURFACES

- A. Protection of Concrete: Under no circumstances shall the Contractor pour and leave the fresh concrete open to vandalism, while it is setting up. Damaged concrete shall be subject to rejection by the Landscape Architect.

3.13 ACCEPTANCE STANDARDS

- A. The following acceptance standards shall be applied to this Contract. Any portion of the concrete paving that does not meet these required acceptance standards shall be removed at the direction of the Owner's Representative. Saw cut pavement at nearest adjacent tooled joint, remove concrete pavement and discard off site in a legal manner and replace with new concrete pavement meeting the requirements of this Section.
 1. Pavement surfaces shall be free of all cracking.
 2. Pavement surfaces shall not pond water.
 3. Pavement surfaces shall be free of visible high and low spots.
 4. Steel mesh reinforcing shall not penetrate the surfaces or sides of the concrete slab.
 5. Sawcut joints and all expansion joints shall be straight, true, uniform in width and free from twists, bends, kinks and misalignments.
 6. Edges and the associated edging patterns shall be consistent, true, crisp and complete.
 7. Pavement shall show no graffiti. Pavement shall show no rubbed surfaces indicative of attempts to erase graffiti.
 8. Expansion joints and score joints shall be placed where identified on the Drawings
 9. Concrete surfaces shall be free of all stains, including those created during the course of the

construction by the Contractor, caused by natural events, or caused by vandalism.

10. All sawcut joints and expansion joints shall be flush.
11. Pours different in color as determined by the Owner's Representative.
12. Pours without expansion joints cast into them shall be removed.
13. Pours not conforming to the Contract Documents shall be removed.
14. All forms shall be removed from the site.

END OF SECTION

SECTION 32 16 00

CURBING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. This section is only a portion of the Contract Documents. All of the Contract Documents, including Conditions of the Contract and Division 1 General Requirements, apply to this section.

1.02 DESCRIPTION OF WORK

- A. The work of this Section includes, but is not limited to the following:
1. Vertical Granite Curb, raised and flush
 2. Precast Concrete Curb
 3. Flush Cast-in-Place Concrete Curb
 4. Formed Asphalt Curb – Cape Cod Berm
- B. Refer to Section 32 18 23 Synthetic Turf for cast-in-place concrete turf edger curb.
- C. Sustainable Building Requirements:
1. The Contractor is to implement practices and procedures to meet the project's sustainable performance goals, which include achieving LEED v4 Silver certification based on USGBC's "LEED Version 4 for Building Design and Construction: Schools" (LEED v4 BD+C: Schools).
 2. The work of this Section includes responding to Architect or Contractor requests for additional information or product data and may be required following initial Green Building Certification Institute (GBCI) review of LEED Application.
 3. Product substitution requests are subject to additional LEED submittal requirements including, but not limited to, Environmental Product Declarations (EPD), Health Product Declarations (HPD), and General Emissions Testing.

1.03 RELATED WORK

- A. Carefully examine all of the Contract Documents for requirements that affect the work of this Section. Other specification sections that directly relate to the work of this Section include, but are not limited to, the following:
1. Section 023000 – Subsurface Investigation
 2. Section 129300 – Site Furnishings
 3. Section 312000 – Earthwork
 4. Section 312500 – Erosion and Sedimentation Controls

5. Section 321216 – Asphalt Paving
6. Section 321313 – Exterior Concrete
7. Section 323000 – Site Improvements
8. Section 323100 – Fencing
9. Section 329000 – Planting
10. Section 329115 – Planting Soils
11. Section 329200 – Turf and Grasses
12. Section 331000 – Water Utilities
13. Section 333000 – Sanitary Sewerage Utilities
14. Section 334000 – Storm Drainage Utilities

1.04 INTENT

- A. The intent of the work of this Section is to provide curbing which at a minimum complies with Commonwealth of Massachusetts, Department of Transportation, “Standard Specifications for Highways and Bridges,” (hereinafter referred to as SSHB) Section 500, “Curb and Edging” and to more stringent requirements specified herein.
- B. Department of Public Works: All work within any public way and all work affecting any public way, including without limitation, roadways, sidewalks, curbs, and other work shall be done in strict compliance with the requirements of the authority having jurisdiction including local and State Standard Specifications, except when Standard Specifications are in conflict with these specifications, the most restrictive and inclusive requirements shall govern.

1.05 SUBMITTALS

- A. Shop Drawings: The name of the Contractor shall be shown on the shop drawings. Finished work shall conform to approved samples and shop drawings.
 1. Provide large scale, detailed and complete shop drawings/placement drawings showing all curbing work including all dimensions, radii, straight and radial transition curbs for accessible curb cuts with lengths clearly indicated.
 2. Provide an itemized schedule of all curb pieces. Curbing shall be individually listed by type with radius and straight pieces noted with their lengths. Tapered, transition and corner curbs shall be individually listed.
- B. Product Data: Submit manufacturers’ certifications stating that materials comply with requirements.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials and products adequately protected against damage. Handle in strict compliance with manufacturer’s instructions and recommendations and store off the ground. Protect from all possible damage including, but not limited to, chipping, staining, cracking and other damage. Cracked, chipped, or stained units will be rejected and shall not be utilized in this work. Sequence deliveries to avoid delays, but minimize on-site storage.

1.07 COORDINATION

- A. The work of this Section shall be coordinated with that of other trades affecting or affected by the work of this Section, including paving work to be done by others, as necessary to assure the steady progress of the Work.

PART 2 - PRODUCTS

2.01 GRANITE CURB

- A. Granite shall be "New England" structural granite conforming to ASTM C 615, Class I Engineering Grade, suitable for curbstone use.
 - 1. Curb shall be light gray, free from seams which impair structural integrity, and with percentage of wear less than 32 percent, as determined by ASTM C 131.
- B. Vertical Granite Curb: Furnish vertical granite curbing, type VA-4 as described in Section M9.04.0 and M9.04.1 of the Massachusetts Department of Transportation SSHB. All curb shall be light gray in color, free from seams and other structural imperfections or flaws which would impair its structural integrity, and of a smooth splitting appearance. The top surface shall be sawed to an approximate true plane, and shall have no projections or depressions greater than 1/8 inch. The front and back arris lines shall be pitched straight and true and there shall be no projections on the back surface for 3 inches down from the top that would exceed a batter of 4" per foot. The front surface shall be at right angles to the planes of the top and ends and shall be smooth quarry split, free from drill holes. Minimum length shall be 6 feet unless otherwise shown on the Drawings.
 - 1. Radial type VA-4 curb shall be used on all curves with a radius of 100 feet or less, where vertical granite curb is called for on the Drawings.
- C. Vertical to Flush Transition Curb: Furnish vertical to flush transition curbs of same material as adjacent curb where shown on the drawings, to taper the reveal of the reveal of the curb from 6 inches to 0 inches. Transition curb along a curve shall be of the same radius. The curb shall be manufactured for the purpose intended at the plant and shall not be field cut.

2.02 MORTAR

- A. Cement mortar shall conform to Section M4.02.15 of the Massachusetts Department of Transportation SSHB: Cement mortar shall be composed of 1-part Portland cement and 2 parts of sand by volume with sufficient water to form a workable mixture. Cement, sand, and water shall conform to M4.01.0: Portland Cement, M4.02.02 Aggregates, Paragraph B, and M4.02.04: Water respectively.
- B. Concrete for curb setting shall be 5,000 lb. concrete as specified in Section 32 13 13 – CONCRETE PAVEMENTS.

2.03 PRECAST CONCRETE CURB

- A. Furnish precast concrete curb to sizes, shapes and dimensions shown on the Drawings. These materials shall conform to the following requirements:
 - 1. Precast concrete curb shall be Portland cement Type I. Cement concrete shall be air-entrained 5,000 psi, ¾-inch, 705 pounds. Curbstones shall be 6" x 18 x 6'-0" typically.

2. Precast concrete curb shall be a standard product. Chamfered edges shall be no greater than 5/8" shall be accepted. Adjacent surface shall meet the flush top of precast concrete curb.
- B. Precast concrete curb construction methods shall comply with the requirements of Section 500 of the Mass. SSHB, as last amended.
1. Precast concrete curb shall be set on a six inch select gravel base, unless otherwise indicated on the Drawings, and to the required line and grade.
 2. Unless otherwise indicated on the Drawings, curbing shall be set in a trench, which shall have been excavated to a width of 18 inches. The subgrade of the trench shall be at a depth of six inches plus the depth of the curbstone. Subgrade shall then be filled to proper level to support curb at final grade. Fill for this purpose shall consist of fine gravel or very coarse sand and a dry mortar pack concrete thoroughly tamped.
 3. Set all curb with continuous concrete setting bed. Concrete shall be as specified herein for footings.
 4. Curb units shall be placed in accurate line, each piece butting the next with maximum joint spacing no larger than ¼-inch. Final points shall be joined by closure pieces made to order. No curb stone shall be cut in the field. After alignment, curb shall be carefully backfilled with suitable material. Extreme care shall be taken not to destroy alignment.
 5. Curb shall be set at line and grade required and shall project 6" above pavement grade, unless otherwise noted on Drawings. All curbing shall be installed prior to installation of the adjacent finished surfaces.

2.04 FLUSH CAST-IN-PLACE CONCRETE CURB

- A. Concrete for Cast-in-Place Concrete Curb shall have a 28-day compressive strength of at least 5,000 pounds per square inch. Higher minimum compressive strength indicated in the drawings and/or specifications for individual improvements shall govern see section 32 13 13 Exterior Concrete.
- B. Fiber reinforcing shall be Matrix Fibrillated Fibers by FRC Industries of Freeport, FL 888-783-2517. Alternative approved manufacturers include:
1. Sika Corporation, New Jersey, 201-933-8800
 2. Cemex, Alabama, 205-841-4711
- C. MATRIX fibrillated fibers are manufactured from 100% homopolymer, virgin polypropylene resin, containing no reprocessed olefin materials, and in compliance with ASTM C-1116-97 "Standard specification for fiber-reinforced concrete and shotcrete." FRC Fibers are specifically engineered for use in concrete as secondary reinforcement, and for the purpose of controlling plastic shrinkage and settlement cracking. FRC Fibers comply with requirements as defined in the 1997 Uniform Building Code – ICBO, and in the National Building Code – SBCCI.
- D. Provide smooth broom finish at all exposed concrete curbing.

- E. Fence posts shall be embedded directly within curb as indicated on the Drawings. Fence posts surfaces shall remain free and clear of dirt and debris as well as remain free of damage as a result of the concrete work.
- F. Sawn control joints at a maximum 20 feet spacing or as indicated in the Drawings shall be perpendicular to concrete curb and penetrate 1 inches minimum into edger. Care should be taken to avoid chipping or damage to concrete curb.

2.05 ASPHALT BERM

- A. Asphalt Berm: Berms shall consist of Class I Bituminous Concrete, Type I-1, Top Course conforming with the Job-Mix Formula given in Section M, paragraph M3.11.03, SSHB and in accordance with the details of design as shown on the Drawings. Asphalt content of mix formula for bituminous berms shall be 6.0 – 9.0 percent by weight of total mix. SEE SECTION 32 12 16 - Asphalt Paving.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. All curbing shall be installed after the installation of the Binder Course and prior to installation of the Top Course. Curb shall be set to the line and grade required and shall project above finished grade elevations in accordance with the Details.
- B. Preinstallation Examination Required: The installer shall examine previous related work, and conditions under which this work is to be performed and notify Contractor in writing of all deficiencies and conditions detrimental to the proper completion of this work. Beginning work means installer accepts substrates, previous work, and conditions.
- C. Manufacturer's Instructions: Strictly comply with Mass. S.S.H.B. including Section 500 of the latest edition for the installation of specified curb, unless these specifications are more restrictive. In such cases these specifications will prevail.
- D. Trench Preparation: Curb shall be set in a trench excavated to a width of 20 inches. The bottom of the trench shall be 6 inches deeper than the depth of the curbstone. The subgrade shall then be filled to proper levels with a minimum of 6 inches of compacted gravel borrow at the lines and grade shown on the plan to provide continuous support to the bottom of curb. Gravel borrow shall be thoroughly rammed or tamped until firm and unyielding.
- E. Granite Curb Installation: Set curbs true to line and grade with vertical exposed curb faces plumb and with curb top surface parallel to adjacent surfaces. The maximum space between joints shall not be more than 1/4 inch. Place concrete continuously along the front and back of the curb as indicated on the Detail. The curbing contractor shall confirm true vertical and horizontal alignment immediately after setting concrete and adjust curb sections as necessary to provide a true line. Joints as described under pointing below.
 - 1. At flush granite planter curb conditions, concrete placement shall be at joints only.
- F. Pointing Joints in Granite and Precast Concrete Curb: The joints between curbstones and edging (both front and back) shall be carefully filled with cement mortar and neatly pointed on the top and front exposed portions. After pointing, the curbstones or edging shall be satisfactorily cleaned of all excess mortar that may have been forced out of the joints and that

may be on the exposed surfaces of the curb.

- G. Tolerances: The following installed tolerances are allowable variations from locations and dimensions indicated by the Contract Documents and shall not be added to allowable tolerances indicated for other work.

1. Allowable Variation from True Plumb: 1/8-inch over exposed face
2. Allowable Variation from True Line: 1/4-inch in 20-feet

- H. Bituminous Berm: The bituminous concrete mixture shall be machine formed by a self-powered curbing machine capable of extruding and compacting the mixture, free of honeycombs, to the line, grade and cross-section shown on the Drawings. The curbs shall be installed on the Binder Course prior to the installation of the Top Course.

- I. Refer to Section 32 13 13 Concrete for installation of Flush CIP Concrete Curb.

3.02 REPAIR, CLEANING AND PROTECTION

- A. Repair minor damage to eliminate all evidence of repair. Clean exposed surfaces using non-abrasive materials and recommended methods. Remove and replace damaged or unsuitable work that cannot be successfully cleaned or repaired.
- B. Provide temporary protection to ensure work is without damage or deterioration at time of final acceptance. Remove protections and re-clean as necessary immediately before final acceptance.
- C. After completion of the work in this Section, the Contractor shall remove all debris, materials, rubbish, etc. from the site and legally dispose of them. New or existing improvements that have been damaged in the work under this Contract shall be repaired to the satisfaction of the Architect.

END OF SECTION

SECTION 321723
PAVEMENT MARKINGS

PART 1-GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

- A. Work Included: Provide labor, materials and equipment necessary to complete the work of this Section, including but not limited to the following:
 - 1. Furnishing and placing of the pavement markings as indicated on the Contract Drawings and as herein specified.
 - 2. All associated items and operations required to complete the installations, including layout of work, surface preparation, application of markings, protection of markings, and accommodations for traffic.
- B. Alternates: Not Applicable.
- C. Items To Be Installed Only: Not Applicable.
- D. Items To Be Furnished Only: Not Applicable.
- E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
 - 1. Section 321313 – CONCRETE PAVING for installation of cement concrete paving for driveways, walkways, and sidewalks.
 - 2. Section 321216 – ASPHALT PAVING for hot-mix asphalt pavement for roadways, parking lots, walkways, berms, and curbs.

1.3 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
 - 1. Product Data: For each type of traffic and zone marking paint product. Include technical data and tested physical and performance properties.
 - 2. Shop Drawings: Indicate pavement markings, lane separation, and defined parking spaces. Indicate, with international symbol of accessibility, spaces allocated for people with disabilities.

1.4 REFERENCE STANDARDS

- A. The following standards are applicable to the work of this Section to the extent referenced herein:

1. Commonwealth of Massachusetts, Massachusetts Department of Transportation (MassDOT), Highway Division, Standard Specifications for Highways and Bridges, latest English Edition with amendments. All references to method of measurement, basis of payment and payment items in the Standard Specifications are hereby deleted. References made to particular sections or paragraphs in the Standard Specifications shall include all related articles mentioned herein.
2. MUTCD: Manual on Uniform Traffic Control Devices.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.
- B. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.

1.6 EXAMINATION OF SITE AND DOCUMENTS

- A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Construction Documents, or obvious from observation of the site.
- B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified pavement marking installer whose work has resulted in successful establishment pavement markings.
 1. Installer's Field Supervisions: Require Installer to maintain an experienced full-time supervisor on Project Site when work is in progress.
- B. Pavement markings shall be in accordance with the MUTCD.

1.8 PROJECT CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.
- B. Weather Limitations: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 55 deg F for water-based materials, and not exceeding 95 deg F.

PART 2-PRODUCTS

2.1 FAST DRYING WATER-BORNE TRAFFIC PAINT

- A. Fast Drying White Water-borne Traffic Paint and Fast Drying Yellow Water-borne Traffic Paint as specified in the MassDOT Standard Specification Sections M7.01.23 and M7.01.24, respectively. Traffic paint shall be lead free, VOC compliant, fast drying, 100% acrylic waterborne traffic paint. Traffic paint shall conform to the performance specifications referenced in Federal Specification TT-P-1952E Type I & II, Federal Specification TT-P-195F Type I & II.
- B. Pavement markings shall be "white" or "yellow" in color, unless otherwise noted on Contract Drawings.
- C. General pavement marking delineation for parking stalls shall measure 4 inches in width. All other pavement-marking widths are shown in detail on the Contract Drawings.

PART 3-EXECUTION

3.1 GENERAL

- A. Pavement markings shall be applied in accordance with MassDOT Standard Specification Section 860 and in accordance with the manufacturer's specifications and requirements.
- B. Do not apply pavement-parking paint until layout, colors, and placement have been verified with the Owner's Representative and/or the Designer.

3.2 SURFACE CONDITION AND PREPARATION

- A. Asphalt and concrete surfaces shall be cured, clean, dry, and sound. The surface shall be free of sand, grease, oil or other foreign substances.
- B. Prior to application of traffic paint the Contractor shall:
 - 1. Sweep and clean pavement surface to eliminate loose material and dust.
 - 2. Remove loose and lifting paint.
 - 3. Remove by etching or abrasive blasting concrete pavement with sealers containing silicone, having a smooth finish, efflorescence or other conditions that may interfere with adhesion.
- C. Allow new asphalt surfaces to cure for one (1) to two (2) weeks before application of traffic paint.

3.3 APPLICATION

- A. Pavement markings shall be applied only in seasonable weather and in accordance with good painting practices. Apply when air and surface temperatures are above 50°F and relative humidity is below 85%. If work has started and air temperatures fall below 50°F and continuous cooling is forecasted, work shall be stopped. Starting work at air temperatures lower than 50°F shall not be allowed.
- B. Contractor shall apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates

to provide a minimum wet film thickness of 15 mils. When the paint must be applied on new asphalt, apply two thin coats 7-8 mils each, allowing 24 hours between coats.

- C. No thinners shall be used for pavement marking applications.
- D. To improve spraying, Contractor may heat paint to the optimum temperature specified by the manufacturer. No paint material shall be heated above the temperature specified by the manufacturer.
- E. If for any reason material is spilled or tracked on the pavement, or any markings applied by the Contractor fail to conform to the Contract Documents because of a deviation from the required pattern, the Contractor shall remove such material by a method that is not injurious to the roadway surface and is acceptable to the Owner's Representative and/or the Designer, clean the pavement surface and prepare the surface for a reapplication of markings and reapply the markings as indicated on the Contract Documents without additional compensation for any of the foregoing corrective operations.
- F. Contractor shall protect pavement markings until sufficiently dry to bear traffic.

3.4 INSPECTION

- A. All materials and each part or detail of the work shall be subject to observation by the Owner's Representative and/or the Designer. The Owner's Representative and/or the Designer shall be allowed access to all parts of the work and shall be furnished with such information and assistance by the Contractor as is required to make a complete and detailed inspection, (such assistance may include furnishing labor, tools, and equipment, at no expense to the Owner).
- B. Any work done or materials used without authorization by the Owner's Representative and/or the Designer may be ordered removed and replaced at the Contractor's expense. The Contractor shall furnish written information to the Owner's Representative and/or the Designer stating the original sources of supply of the materials manufactured away from the actual site of the work. In order to ensure a proper time sequence for required inspection and approval this information shall be furnished at least two weeks (or as otherwise directed by the Owner's Representative and/or the Designer) in advance of the incorporation in the work of any such materials.
- C. For the purpose of observing work that affects their respective properties, inspectors for the municipalities, public agencies and the utility companies shall be permitted access to the work, but all official orders and directives to the Contractor will be issued by the Owner's Representative and/or the Designer.
- D. The observation of the work shall not relieve the Contractor of any of his obligations to fulfill the terms of the Contract as herein prescribed by the Contract Documents.
- E. Failure to reject any defective work or materials shall not in any way prevent later rejection when such defect is discovered or obligate the Owner's Representative and/or the Designer to make final acceptance.

END OF SECTION

SECTION 32 18 16.13
PLAYGROUND PROTECTIVE SURFACING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 apply to the work of this Section.

1.02 DESCRIPTION OF WORK

- A. Provide all labor, equipment, implements and materials required to furnish, install, construct and perform all paving operations complete as shown on drawings and specified herein.
- B. Work includes, but is not limited to the following:
1. Grading and Compacting of Subbase
 2. Poured-in-Place Rubber Safety Surfacing
 3. Cleaning, Repair and Protection

1.03 RELATED WORK

- A. Carefully examine the site and all of the Contract Documents for requirements that affect the work of this Section. No claim for additional costs will be allowed because of lack of full knowledge of existing conditions. Other specifications sections that directly relate to the work of this Section include, but are not limited to, the following:
1. Section 11 68 00 – Playground Equipment
 2. Section 12 93 00 – Site Furnishings
 3. Section 31 00 00 – ~~Earthwork~~ **Earth Moving (ADD A1, 03/12/21)**
 4. Section 32 30 00 – Site Improvements
 5. Section 33 40 00 – Storm Drainage Utilities
- B. The work of this Section shall be coordinated with that of other trades affecting, or affected by, this work, as necessary to assure the steady progress of all work of the Contract.

1.04 REFERENCES

- A. The following related items are included herein and shall mean:
1. S.S.H.B. - Standard Specifications for Highways and Bridges, the Commonwealth of Massachusetts, Department of Public Works, latest edition.
 2. A.S.T.M. - American Society for Testing and Materials.
- B. American Society of Testing and Materials (ASTM)
1. 355 Shock Absorbing Properties of Playing Surface Systems and Materials (GMAX)
 2. F1292 Impact Attenuation of Surface Systems Under and Around Playground

Equipment

3. F1951 Determination of Accessibility of Surface Systems Under and Around Playground Equipment

1.05 SUBMITTALS

- A. Submit manufacturer's Product Literature including certification, Specification Data and installation instructions.
 1. Provide a physical sample
 2. Submit test results for impact attenuation in accordance with ASTM F 1292 Standard Specification and accessibility in accordance with ASTM F1951.
 3. Provide Manufacturer's Warranty for Owner's acceptance.
 4. Submit test results for impact attenuation in accordance with ASTM F 1292 Standard Specification and accessibility in accordance with ASTM F1951. Submit evidence of IPEMA (International Playground Equipment Manufacturer's Association) certification.
- B. Submit installer qualifications (Manufacturer-certified installer of system).
 1. Installers of the synthetic turf surface system shall have five (5) years minimum experience and shall provide three (3) local references where installation can be inspected.
- C. The General Contractor shall verify by field inspection that all items within this section conform to the specified requirements and approved submittals prior to installation

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials and products and provide adequate protection against damage. Handle in strict compliance with manufacturer instructions and recommendations and store off the ground. Protect from all possible damage including, but not limited to chipping, staining, cracking and other damage. Sequence deliveries to avoid delays, but minimize on-site storage.

1.07 COORDINATION

- A. The work of this Section shall be coordinated with that of other trades affecting, or affected by, this work as necessary to assure the steady progress of the work of this Contract.
- B. Start of work under this Section shall constitute acceptance of the foundation conditions to which this work is to be applied. Any defects in work resulting from such conditions shall be corrected under this Section, at no extra cost to the Owner.
- C. Substrates: Proceed with work only when substrate construction and penetrating work is complete. Maintain the sub-base in satisfactory condition and properly drained until surface improvement is placed.

1.08 GUARANTEE

- A. The Contractor shall deliver standard written manufacturer's guarantee in the Owner's name covering all materials and workmanship. In addition to the specific guarantee requirements of the GENERAL CONDITIONS and SUPPLEMENTARY GENERAL CONDITIONS, the Contractor shall provide the manufacturers' standard written warranty for each product within this specification. All of these guarantees shall be in addition to, and not in lieu of, other liabilities that the Contractor may have by law or other provisions of the Contract Documents.

1.09 QUALITY ASSURANCE:

- A. Surface Installer Qualifications: Company specializing in outdoor resilient surfaces in the USA and certified members of NPCAI. The applicator shall be approved and trained, with a minimum of five years' documented experience and have completed 5 public playgrounds in the past 5 years. Conditions of all surface substrates with respect to structural performance shall be evaluated and approved by the surface installer prior to application of surface system.
- B. Performance requirements
1. All safety surfacing within playground equipment use zones shall meet or exceed the performance requirements of the CPSC, ADA and Fall Height Test ASTM F 1292 and IPEMA certified for the highest playing point of each piece of play equipment.
 2. Surfaces intended to serve as accessible routes of travel shall be firm, stable and slip resistant and shall be meet the requirements of ASTM F 1951 and ASTM F 1292
- C. Post-installation testing
1. Impact attenuation testing shall be performed by a National Recreation and Parks Association/National Playground Safety Institute (NRPA/NPSI) Certified Playground Safety Inspector (CPSI) and trained in the proper operation of the Triax test equipment.
 2. Impact attenuation testing shall be performed according to ASTM 1292 in presence of the owner within 30 days of installation. As a precondition of surfacing acceptance, the Contractor shall provide the testing results in writing. Up to 10 drop test locations will be required at each separate play area.
 3. If the surfacing does not meet the safety standards or impact attenuation performance requirements, the contractor will be required to bring the surfacing up to compliance within 30 days or less. The extent of failure and determination of replacement will be at the discretion of the Owner. Should they be found during or after installation, any violations of the C.P.S.C. Guidelines, ASTM, ADA or impact attenuation performance requirements shall be corrected to the satisfaction of the owner, any proposed corrective work shall be reviewed and approved by the Landscape Architect before corrective work begins.
 4. Impact attenuation requirements: Gmax test results shall be less than 150 and HIC test results shall be less than 850
 - a. Please refer to the falling fall height zones for safety surfacing minimum depth. Actual depths shall be adjusted (thickened) as needed by contractor to accommodate the final Gmax and HIC requirements.

FALL HEIGHT	
PIP DEPTH	FALL HEIGHT
2.5"	4'
3"	5'
3.5"	6'
3.5"	7'
4"	8'
4.5"	9'
5"	10'
6"	12'

PART 2 - PRODUCTS

2.01 GRADING AND COMPACTION OF SUB-BASE

- A. Do all necessary grading in addition to that specified under ~~Section 31 00 00 — EARTHWORK~~ **Section 31 00 00 Earth Moving (ADD A1, 03/12/21)** to bring subgrade or foundation after final compaction to required grades and sections to obtain a foundation of uniform bearing surface. In absence of specific requirements, compact foundation by such means as will provide firm base and insurance against settlement of superimposed work.
- B. Sub-base preparation, including material, shall be of properly approved quality as specified under ~~Section 31 00 00 — EARTHWORK~~ **Section 31 00 00 Earth Moving (ADD A1, 03/12/21)**. Start of work under this Section shall constitute acceptance of the foundation conditions to which this work is to be applied. Any defects in work resulting from such conditions shall be corrected under this Section, at no additional cost to the Owner.

2.02 SYNTHETIC TURF SAFETY SURFACING

- A. Furnish and install Synthetic Turf Safety Surface complete with gravel base, binder, sub drainage and edging per the Contract Documents.

To establish a standard of quality, design, and functionality desired, Drawings and Specifications have been based on the material "SynLawn Playground System" by Altantic Sports Group (www.atlaticsg.com) Contact: Scott Koesterich (scott@atlaticsg.com) Ph: 781 821 0112

1. The basis of design product is "SynLawn Play Premium" with the following specifications:

SKU	ST343_PLAY
Grass Zone Yarn/Color	PE / Field Green / Apple
Grass Zone Denier	10,800 / 6
Thatch Zone Yarn/Color	PE / Field Green / Beige
Thatch Zone Denier	5,000 / 8
Grass Zone Yarn Shape	Omega
Finished Pile Height	1 1/2"
Finished Pile Weight	80 oz.
Backing	13PP/18PET 2pt / 22oz. EnviroLoc+™
Tuft Gauge	3/8"
Total Weight	108 oz.
Tuft Bind	> 8 lbs.
Permeability	> 1,000 inches p/hr
Features	Sanitized*, EnviroLoc+™, StatBlock™ Anti-Static, DualChill™ IR Reflective, Deluster, UV Stabilizers
Test Data	ASTM E108 CLASS A FIRE, D2859, E648, F1292, F1551, F1951, CAL 1350, PFA-FREE

PART 3 - EXECUTION

3.01 SUBBASE, EDGER AND DRAINAGE

- A. Install edger system in accordance with the drawings and per the manufacturer's recommendations. Install the underdrainage as indicated on the Drawings. Install gravel base where indicated on the drawings and in accordance with ~~Section 31 00 00 Earthwork~~ **Section 31 00 00 Earth Moving (ADD A1, 03/12/21)**. Install underdrainage in accordance with Section 33 40 00 - Storm Drainage Utilities.

3.02 SYNTHETIC TURF SAFETY SURFACE

- A. Installation shall be as recommended by the manufacturer and shall be to the depths and widths indicated on the drawings.
- B. Do not proceed with playground surfacing installation until all applicable site work, including substrate preparation, fencing, concrete edge restraints, playground equipment installation and other relevant work has been completed.
- C. Synthetic Turf surfacing must be installed on a dry subsurface with no prospect of rain within the initial drying period and within recommended temperature range (40 degree Fahrenheit and rising) of the manufacturer.
- D. The contractor shall provide copies of testing procedures and results, performed by an independent testing source, which demonstrate compliance with the CPSC and ASTM guidelines. Per CPSC and ASTM F-1292 Critical Height testing procedures at 30, 72, and 120 degrees F, the installed surface shall pass the 150 G-max and 850 HIC test for a height at least equal to the highest fall height of equipment as installed within its zone.
- E. When installed, the system shall be handicapped-accessible and comply with the Civil Rights Restoration Act of 1987 and the Americans with Disabilities Act of 1990 (ADA). Surface must comply with Massachusetts Architectural Access Board accessibility requirements and ASTM F1951.
- F. Contractor shall provide a written five (5) year performance guarantee from date of substantial completion. The manufacturer shall provide a written guarantee for three (3) years from date of installation against decay and biochemical degradation calling for replacement of defective materials during the guarantee period. Contractor shall install system so as to comply with manufacturers' warranty requirements.

3.03 CLEANING, REPAIR AND PROTECTION

- A. Repair minor damage to eliminate all evidence of repair. Remove and replace work that cannot be satisfactorily repaired.
- B. Provide temporary protection to ensure that the work will be without dirt, stains, damage or deterioration at time of final acceptance. Clean up stains and spills as they occur. Remove protections and clean as necessary immediately before final acceptance.
- C. Upon completion of the work and before acceptance, the Contractor shall remove and dispose of in an approved manner all surplus materials, rubbish, etc. which the Contractor may have accumulated during the course of the work and shall leave the site in a clean and orderly condition. The Contractor shall not abandon any material at or near the site regardless of whether it has any value.

END OF SECTION

SECTION 32 18 23
SYNTHETIC TURF

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide the complete installation of an infilled synthetic turf system and shock pad from the prepared subgrade to the finished grade within area as indicated on the Contract Drawings.
- B. Provide the complete installation of a passive-use synthetic turf system and shock pad on the prepared building roof within the areas as indicated on the Contract Drawings.
- C. Fine grade subgrade surface to meet subgrade elevations within the area to receive the synthetic turf system.
- D. Provide and install reinforced concrete curb in accordance with Section 321313.
- E. Provide and install geotextile filter fabric over the entire subgrade area to receive the synthetic turf system.
- F. Provide and install flat panel drains as specified under Section 334000
- G. Provide, place and compact stone base layers as per requirements of Part 3 Execution, as specified herein and Section 31 20 00 - Earth Moving. Protect drainage pipe from damage during grading operations.
- H. Fine grade top of synthetic turf stone base to within manufacturer's tolerance for the synthetic turf installation.
- I. Furnish and install approved shock pad.
- J. Provide and install the complete synthetic turf system from the manufacturer approved by the Landscape Architect.
- K. Provide and install access frame kit at goal posts where required on the Drawings.
- L. Testing and certifying of installed system shall be at the Contractor's expense.
- M. Corrective measures as necessary for system to meet the manufacturer's requirements and the performance characteristics specified herein and in Section 312000 Earth Moving.
- N. The work of this Section shall be coordinated with that of other trades affecting, or affected by, this work, as necessary to assure the steady progress of all work of the Contract.

1.2 RELATED WORK

- A. Carefully examine all of the Contract Documents for requirements that affect the work of this Section. Other specification sections that directly relate to the work of this Section include, but are not limited to the following:

1. Section 012300 – Alternates.
 2. Section 075400 Thermoplastic Membrane Roofing systems beneath passive-use synthetic turf.
 3. Section 116833 – Athletic Field Equipment.
 4. Section 312500 – Erosion and Sedimentation Control.
 5. Section 312000 – Earth Moving.
 6. Section 321600 – Curbing.
 7. Section 321313 – Exterior Concrete.
 8. Section 334000 – Storm Drainage Utilities.
 9. Section 323100 – Fencing.
- B. Sustainable Building Requirements:
1. The Contractor is to implement practices and procedures to meet the project's sustainable performance goals, which include achieving LEED v4 Silver certification based on USGBC's "LEED Version 4 for Building Design and Construction: Schools" (LEED v4 BD+C: Schools).
 2. The work of this Section includes responding to Architect or Contractor requests for additional information or product data and may be required following initial Green Building Certification Institute (GBCI) review of LEED Application.
 3. Product substitution requests are subject to additional LEED submittal requirements including, but not limited to, Environmental Product Declarations (EPD), Health Product Declarations (HPD), and General Emissions Testing.

1.3 QUALITY ASSURANCE

- A. Manufacturer/Installer Qualifications: The installation contractor for the synthetic turf shall be a certified installer, certified by the manufacturer of the approved turf system. The preparation, construction and installation of the synthetic turf field system shall be completed by a contractor specializing in synthetic turf field construction who shall have completed ten (10) synthetic turf field projects, each 80,000sf or larger, utilizing a similar system proposed for this work, in the last five (5) years. Subcontracted labor and or supervisors are not acceptable. The installer must have at least three years of continuous business under the same name and or organizational structure. Business alliances, joint ventures or partnerships formed to comply with any of these qualification requirements shall not be accepted. The installation contractor shall submit references from all synthetic turf installations they have performed within the past five (5) years to include the Owner's contact name, address and phone number. The manufacturer shall submit references from at least seven (7) installations of the same specified system.
- B. To ensure quality control and workmanship, the installation company's supervisor for this project shall be the primary installation company's representative on-site, to oversee the complete installation work. Part-time or replacement personnel will not qualify as the installation supervisor during any part of the installation process, unless the contractor provides written qualifications for the replacement supervisor to the architect for approval. Approval from the architect must be received prior to the replacement personnel's involvement with this installation.
- C. The manufacturer's representative shall be present (on site) during the installation process to approve the following system components. Approval of the subgrade preparation and subdrain installation; geotextile filter fabric; drainage stone installation; fine grading of the top of drainage stone and the installation of the synthetic turf.
- D. All designs, markings, layouts and materials shall conform to all standards and rules of the applicable state, national and/or international governing body.

- E. Source limitations: All components of the Synthetic Turf system shall be provided from a single-source Synthetic Turf System Manufacturer.
- F. Seams between turf panels shall be glued. Turf panels shall be 15-feet in width.
- G. Field markings shall be tufted in and incorporated into the continuous urethane backing (no seams) of the turf panel rolls during the manufacturing process, to the extent which the approved manufacturer is capable. All other field markings shall be inlaid. Approval by the Landscape Architect is required prior to that start of the inlaid markings
- H. 3rd Party Testing: Where specified herein, an independent third party testing agency shall be retained by the Contractor to perform all required testing. Pre-approved testing agencies include:
 - 1. Firefly Sports Testing – Hooksett, NH tel:603-715-5453
 - 2. Labosport – Dalton, GA tel:706-529-9474
 - 3. Sports Laboratories- Chattanooga, TN tel 423-617-6928

1.4 SUBMITTALS

- A. Items to be submitted prior to ordering materials:
 - 1. Manufacturer and installer qualifications under item 1.03 herein.
 - 2. Specifications of the turf system components' physical properties and assembled system performance characteristics meeting requirements specified herein and industry standards including certification from the turf manufacturer that lead or lead chromate, and PFAS/PFOS are not used in the manufacturing of the specified system. Submit manufacturer's specifications and installation instructions for all products in the synthetic turf system, including certifications and other data to show compliance with the Contract Documents and conformance with material environmental and safety standards and regulations.
 - 3. Warranty terms indicating available coverage and terms as specified under item 1.05 herein.
 - 4. Synthetic turf system manufacturer's certification in writing that their turf system, materials, details and/or installation methods do not violate any manufacturers' patents or patents pending. It is the intent of this Section not to infringe upon any existing patents, licenses or rights of individuals or companies.
 - a. The Contractor and Subcontractors who have submitted the bid, proposal, or request related to these Drawings and Specifications hereby represent and warrant that the products, materials, and processes identified in their bid, proposal, or request: a) do not infringe any patents or other intellectual property owned or controlled by the third party, and b) are not the subject of any notice, allegation, assertion, claim, or suit by a third party that the products, materials, or processes identified in the bid, proposal, or request infringe a patent or other intellectual property owned or controlled by the third party.
 - b. The Contractor and Subcontractors who have submitted the bid, proposal, or request related to these Drawings and Specifications hereby represent and warrant that the products, materials, and processes identified in their bid, proposal, or request: a) do not infringe any patents or other intellectual property owned or controlled by the third party, and b) are not the subject of any notice, allegation, assertion, claim, or suit by a third party that the products, materials, or processes identified in the bid, proposal, or request infringe a patent or other intellectual property owned or controlled by the third party.
 - 5. Provide impact attenuation ASTM F355 (GMAX) and ASTM F1292 Hemisphere Impact Attenuation (HIC) test results of the specified system from prior installations. The test results submitted shall demonstrate that the synthetic turf system for this project shall have a GMAX value as specified herein, that shall not exceed 120 GMAX and a HIC value below

- 1,000 at 1.4 meters during the warranty period or the system's life expectancy.
 6. Submit manufacturer's product data, installation instructions, warranty(s) along with material component samples and a sample of the assembled system (approximately one (1) square foot).
 7. Submit a shop drawing plan at 1"=30' containing all pertinent information regarding installation. Provide a seaming plan at 1"=30', edge details.
 - a. Mock up:
 - 1) Upon acceptance of the completed submittal, the installation contractor shall construct a 2-foot by 2-foot or larger mock up panel on site for approval by the Architect and Owner. The mock up shall include one seam and one edge of the assembled sample, which shall include a tufted line of each color specified, inlaid through the middle to depict materials, color and workmanship.
 - 2) The mock up panel shall be representative in every way of the composition, strength, color, texture, installation details, and performance of the material to be assembled as the finished system and may be tested for comparison with submitted test data.
 - 3) The mock up shall be used as a quality and performance datum for comparison to the finished installation.
 8. Submit one (1) quart sample of organic/sand turf infill mix at the proper mix ratio.
 9. Submit a sample of the shock pad underlayment.
 10. Submit the full range of fiber colors for selection.
 11. Submit a minimum 18-inch square sample of turf carpet including stitched seam.
 12. Lead Test to meet 2015 CPSC requirements. Not to exceed 50 P.P.M. Refer to section 1.07 as specified herein.
 13. Lab Test Results demonstrating the submitted turf system complies with all One Turf Concept performance and longevity guidelines.
 14. Testing confirmation surpassing 200,000 Lisport Cycles as certified by a 3rd party independent testing agency.
- B. Items to be submitted after manufacturing but prior to installation:
1. Post manufacturing/pre-shipment test results from an independent lab for carpet identification shall include tuft bind, pile height, pile weight, carpet mass, tuft count, Dtex values, lead content in parts per million and EPA Method 537 Modified test results showing non-detect (ND) for 30 PFAS compounds.
- C. Item to be submitted during installation and prior to substantial completion:
1. Compaction, planarity and permeability (infiltration) test results as specified herein demonstrating conformance with specified performance requirements, at least one week prior to installation of the shock pad.
 2. Seam strength testing in accordance with EN 12228 Method 1. Three (3) samples minimum. Seam strength shall be greater than or equal to 300lbs/ft.
 3. Dimensional stability test results in accordance with ASTM D1204 (modified) Linear Dimensional Changes of Nonrigid Thermoplastic Sheeting of Film at Elevated Temperatures. Three (3) samples minimum.
 4. The synthetic turf manufacturer/installer shall submit written certification of their acceptance of the following substrate components, installation and properties prior to installation of the synthetic turf system. Such certification shall be based on field verification of installed conditions and shall include dated and time-stamped photographs documenting these stages of construction.
 - a. Gradation, proctor and permeability test results on samples submitted for the bottom and top drainage layer materials for the base construction of the field.
 - b. Subgrade preparation for proper depth, slope and fine grading prior to installation of

- the geotextile filter fabric.
 - c. Installation of the filter fabric, sub drain pipes and drainage base installation. Drainage base approval shall include acceptance of the compaction, planarity, permeability and stability of the base.
 - 5. Manufacturer's review: Submit written statement signed by the Contractor and synthetic turf surfacing installer stating that the Drawings and Specifications have been reviewed by qualified representatives of the materials manufacturer, and that they are in agreement that the materials and system to be used for synthetic field surfacing are proper and adequate for the applications shown.
 - 6. Submit delivery slips for all Synthetic Turf system materials delivered to the site, to the Owner's representative upon delivery of materials.
- D. Items to be submitted prior to final completion:
- 1. Submit a written statement signed by the manufacturer stating that the field supervision of the manufacturer's representative was sufficient to ensure proper application of the materials, that the work was installed in accordance with the Contract Documents, and that the installation is acceptable to the manufacturer.
 - 2. Provide warranty materials as specified herein, properly executed and registered with the Manufacturer, Contractor and insurance carrier.
 - 3. Provide GMAX, HIC, LEAD, ADA and One Turf Concept testing, as specified herein under item 1.04 & 1.07, and As-Built survey results verifying that the performance of the installed system, meets all requirements of this specification and applicable safety standards and requirements.
 - 4. Provide on-site One Turf Concept testing for performance and longevity on the installed field.
 - 5. Provide three copies of Maintenance Manuals and one (1) digital copy in PDF format, which include all necessary instructions for the proper care and preventative maintenance of the synthetic turf system, including painting and markings.
 - 6. Provide extra and additional materials to the Owner:
 - a. One contiguous green piece of synthetic turf 15' wide by 15' long from the same production run as the turf supplied to this project, as well as all salvageable remnants from the installation.
 - b. Two hundred pounds of specified sand.
 - c. Five hundred pounds of specified organic infill provided in individual 20-40 pound plastic bags.

1.5 WARRANTY

- A. The synthetic turf provider shall provide an eight (8) year pre-paid warranty that is insured by a policy of insurance issued by a reputable insurance company and must have the following policy features:
- 1. Stating that all work executed under this Section will be free from defects in material and workmanship without limitations for a period of eight (8) years from the date of Substantial Completion, and that any defects will be remedied on written notice at no additional cost to the Owner.
 - 2. Coverage of all materials and labor shall provide for all costs up to and including the full value of a complete re-installation of the synthetic turf system and all preparation and disposal costs.
 - 3. This warranty shall include all components of the system in its coverage.
 - 4. The manufacturer shall warrant that materials and their performance shall meet or exceed the product specifications.
 - 5. The warranty shall not limit the types of sports and recreation activities or uses that are typical of similar soccer and football field installations.
 - 6. The insurance premium for this coverage shall be paid in full for the entire length of the

- warranty.
7. Insurance coverage shall specifically provide for reimbursement to the warranty holder in the event of bankruptcy of the synthetic turf provider.
 8. Insurance coverage shall apply to playing surface inclusive of infill, seaming, labor and colored inlays for event markings.
 9. Provide the following documents with bid: Warranty Certificate, Accord Certificate, the actual Insurance Policy, and proof of A.M. Best Rating for the insured warranty provider.
 10. Insurance coverage shall apply to the full 8 year period from completion date of project, with no uninsured periods or periods of self-insurance.
 11. Insurance is provided by a third party insurer with an A.M. Best financial strength rating of "Excellent" or higher.
 12. Insurance coverage shall not have exclusions for epidemic or catastrophic failure.
 13. Insurance coverage shall not limit the hours of use.
 14. Insurance coverage shall not exclude heavy trafficked areas or related uses such as team or band practices.
 15. Insurance coverage shall not exclude any colored turf fibers.
 16. Insurance coverage offers a minimum claim limit of \$5 million in the aggregate per annum.
 17. Insurance coverage offers a minimum claim limit of \$ 300,000 per field.
 18. Provide the actual executed Policy from the insurance carrier.
 19. Include certified evidence that the manufacturer has in place a minimum of \$500,000.00 in cash in a separate warranty reserve account for small warranty repairs.
- B. Response time to perform emergency warranty repairs shall not exceed 24 hours from the time of contact. The warranty shall guarantee the availability of replacement material for the synthetic turf system for the full warranty period. The warranty shall state that the intended use as a multi-purpose field for training and games including the use of cleats is covered under the material and workmanship warranty.
- C. Starting with the completion of construction, the synthetic turf manufacturer/installer shall retain a third party (independent) certified testing laboratory approved by the Owner to perform shock absorption testing once each year during the life of the Warranty in accordance with ASTM F 1936 and ASTM F 355 (G-Max) and ASTM 1292. Testing shall be performed at the field's center, the goal locations for all sports and 10 yards inside each corner. G-Max shall not change more than 5% at any one location per year over the life of the guarantee and at no time shall be less than 85 or greater than 125 at any one point of the field. HIC value at installation and over the life of the guarantee shall be below 1,000 at 1.4 meters for each location. In cases where the results of the testing fall outside this range, the condition shall be repaired and the G-Max re-tested by the manufacturer to return the field to within the specified range.
- D. Within the first 3 months after final acceptance, the turf installation contractor shall replenish the specified infill material to the required depth at no additional cost to the Owner if the depth of the infill is found to have settled to be less than the specified depth throughout the field surface during that timeframe. Only a + tolerance of 1/8" will be accepted for infill depths.
- 1.6 PROJECT CONDITIONS AND COORDINATION
- A. Weather: The turf contractor shall perform work only when permitted by weather conditions meeting the manufacturer's requirements. No part of the construction shall be conducted during a rainfall or when rainfall is imminent.
- B. Coordination: The turf installation contractor shall coordinate work with the General Contractor and his subcontractors. Specific attention is called to the required coordination at all edges of the synthetic turf field area.

1.7 REFERENCES

- A. Comply with all local, state and federal codes and regulations, including all ADAAG regulated testing. Comply with applicable requirements of the latest editions of the following standards. Where these standards conflict with other specified requirements, the most restrictive requirement shall govern.
- B. American Society of Testing and Materials (ASTM).
 - 1. C 131 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
 - 2. D 395 Rubber Property – Compression Test.
 - 3. D 418 Pile Yarn Floor Covering Construction.
 - 4. D 422-63 Particle Size Analysis.
 - 5. D 1335 Tuft Bind of Pile Floor Coverings.
 - 6. D 1557 Laboratory Compaction Characteristics of Soil Using Modified Effort.
 - 7. D 1577 Linear Density of Textile Fibers (Denier).
 - 8. D 1682 Breaking Load and Elongation of Textile Fabrics.
 - 9. D 2256 Breaking Load (Strength) and Elongation of Yarn by the Single-Strand Method.
 - 10. D 2434 Permeability of Granular Soils (Constant Head).
 - 11. D 3776 Mass Per Unit Area (Weight) of Woven Fabric.
 - 12. D 3786 Hydraulic Bursting Strength of Knitted Goods and Non-Woven Fabrics: Diaphragm Bursting Strength Tester Method.
 - 13. D 4491 Water Permeability of Geotextiles by Permittivity.
 - 14. D 4533Trapezoid Tearing Strength of Geotextiles.
 - 15. D 4632Breaking Load and Elongation of Geotextiles (Grab Method).
 - 16. D 4833Index Puncture Resistance of Geotextiles, Geomembranes and Related Products.
 - 17. D 5034 Breaking Strength and Elongation of Textile Fabrics (Grab Test).
 - 18. D 5034-05 Breaking Strength and Elongation of Textile Fabrics (Grab Test Modified for Seam Strength).
 - 19. D 5848 Mass per Unit Area of Pile Yarn Floor Coverings.
 - 20. E1792-96E Standard Specification for Wipe Sampling Materials for Lead in Surface Dust.
 - 21. F 355 Shock Absorbing Properties of Playing Surface Systems and Materials (GMAX).
 - 22. F 1551-97 Comprehensive Characterization of Playing Surface Systems and Materials.
 - 23. F 1936 Shock-Absorbing Properties of North American Football Field Playing Systems as Measured in the Field.
 - 24. F2765 Total Lead Content in Synthetic Turf Fibers.
- C. British Standards Institution.
 - 1. BS 7044, Method 4 Double-ring Infiltrometer (At Owner's discretion).
- D. Massachusetts Department of Transportation Standard Specifications for Roadways and Bridges.
- E. Standard Specifications for Highway Materials and Methods of Sampling and Testing, American Association of State Highway and Transportation Officials (AASHTO).
- F. American National Standards Institute (ANSI).
- G. Consumer Protection Safety Commission (CPSC).
- H. Occupational Health and Safety Administration (OSHA)
- I. Environmental Protection Agency (EPA).
- J. Town of Billerica Engineering Department Standards and Specifications

- K. American Concrete Institute (ACI).
- L. Synthetic Turf Council Guidelines (STC) www.syntheticurfCouncil.org.
- M. American Sports Builders Association Guidelines (ASBA) www.sportsbuilders.org.
- N. Massachusetts Interscholastic Athletic Association (MIAA) www.miaa.net.
- O. National Federation of State High School Associations (NFHS) www.nfhs.org.
- P. National Collegiate Athletic Association (NCAA) www.ncaa.org.
- Q. International Amateur Athletic Federation (IAAF) www.iaaf.org.

1.8 DELIVERY, STORAGE AND HANDLING

- A. Deliver manufactured materials in original packages with seals unbroken and bearing manufacturer's labels indicating brand name and directions for storing.
- B. Store manufactured materials in a secure, clean and dry location protected from the weather, vandalism and deterioration, and complying with manufacturer's written instructions for minimum and maximum temperature requirements for storage.
- C. Store rolls of synthetic turf horizontally on flat surfaces. Do not stand or stack rolls upright.

PART 2 - PRODUCTS

2.1 DRAINAGE BASE AND AGGREGATE

- A. Drainage stone for bottom and top layers indicated on the contract drawings shall be in accordance with Section 312000 Earth Moving
- B. Geotextile Filter Fabric:
 - 1. Non-woven polypropylene geo-textile fabric shall be chemically and biologically inert and shall be equivalent to the following:
 - a. Mirafi 140N, TenCate Geosynthetics North America, Pendergrass, GA 706-693-2226.
 - b. 140EX, LINQ Industrial Fabrics, Inc. Summerville, SC 800-445-4675.
 - c. C45NW, CONTECH Construction Products Inc. West Chester, OH 800-338-1122.
- C. Subdrains:
 - 1. Corrugated Plastic (Polyethylene) Pipe (HDPE) Collector Drains shall be flexible, prefabricated composite product, with a rounded rectangular shape wrapped in geotextile fabric. Rolls shall be 12" wide. The system core shall be made of high-density polyethylene with perforation evenly distributed on both faces of the core. The core collection system shall conform to the following physical properties:

Thickness (1")	ASTM D-1777
Outflow Rate, gpm/ft (29)	ASTM D-4716
Compressive Strength, psf (6000)	ASTM D-1621
Perforations / sq. ft.	≥ 300

- 2. The quality of standard, design and function desired is based on Multi-Flow system,

- manufactured by Varicore Technologies, Inc. (800) 978-8007.
3. Additional acceptable manufacturers include (or approved equal):
 - a. ADS 1-800 821-6710.
 - b. Invisible Structures, Inc. 1.800.233.1510.

2.2 CAST-IN-PLACE CONCRETE TURF EDGER

- A. Concrete for Cast-in-Place Turf Edger shall have a 28-day compressive strength of at least 4,000 pounds per square inch. Higher minimum compressive strength indicated in the drawings and/or specifications for individual improvements shall govern see section 32 13 13 Exterior Concrete.
- B. Concrete shall include fiber reinforcing as specified in Section 321313 Exterior Concrete.
- C. Provide smooth broom finish at all exposed turf edger.
- D. Fence posts shall be embedded directly within curb edger as indicated on the Drawings. Fence posts surfaces shall remain free and clear of dirt and debris as well as remain free of damage as a result of the concrete work.
- E. Sawn control joints at a maximum 20 feet spacing or as indicated in the Drawings shall be perpendicular to turf edger and penetrate 1 inch minimum into edger. Care should be taken to avoid chipping or damage to turf concrete edger.

2.3 SYNTHETIC TURF SURFACE & INFILL SYSTEM

- A. The complete permeable and infilled synthetic turf system submitted to and approved by the Landscape Architect and Owner shall be one of the following specified systems and shall meet all requirements specified herein including, but not limited to, Item 1.03 Quality Assurance, Item 1.04 Submittals and 1.05 Warranty. No other systems will be considered without comprehensive demonstration submitted by the Contractor that an alternative clearly meets all specified material, performance and qualification requirements.
 1. Allsport Ultra by Greenfields USA , Dayton TN, represented by Mark Curran tel 978-761-5340
 2. Rhino Blend by AstroTurf, Dalton, GA, represented locally by Dave Wheaton tel. 413-426-3789
 3. Legion NXT (with Thunderbolt Monofilament) by Shaw Sports Turf, Calhoun, GA, represented locally by Aaron Goebbel tel 508-365-7486
- B. The synthetic turf system shall be considered "PFAS free" according to European REACH standards and California PROP 65. The approved turf system shall be tested after manufacturing to be non-detect (ND) for PFAS formulations identified in EPA Method 537 Modified criteria and have a statement from the synthetic turf manufacturer that the turf system produced for this project is not manufactured with PFAS.
- C. Synthetic Turf Surface:
 1. Physical properties and performance characteristics of the synthetic turf components and system shall meet the manufacturer's standard specifications for the approved synthetic

turf system and the following criteria. The criteria ranges indicated below are intended to permit the variations inherent between the specified turf systems, and do not suggest that such ranges would be acceptable in the finished installation of a particular system. The finished installation of the approved synthetic turf system must have uniform materials and performance throughout the field area.

Polyethylene Fiber Denier	Monofilament-10,800 (min) Slit Film -10,000 (min)
Pile Height	2 inches
System Permeability	>20 inches/hour minimum
Impact Attenuation (GMax)	110 minimum to 165 maximum
Pile Weight	50-55 ounces/square yard
Tuft Bind Strength	> 8 lbs.
Breakload	18 PSI minimum per ASTM D 2256
Elongation at Break	47% minimum per ASTM D 2256
Grab Tear (Width and Length)	>250 lbs/ft

- a. Yarn shall be a UV resistant, multi-structured/parallel fiber extruded of monofilament and slit film polyethylene grass-like fibers with a finished pile height of 2 inches with a +1/8" height tolerance after any shrinkage from manufacturing tufted into a dimensionally-stable primary backing with a secondary urethane backing. Turf systems using yarn or ribbon that shrinks during the manufacturing process shall oversize pile height so that the finish product including any process related shrinkage meets these requirements. Height shall be measured after heating processes that would shrink the fibers. Process related fiber shrinkage shall not relieve the manufacturer from providing a full 2.00-inch product.
- b. The turf shall be suitable for all field sports, marching band, and all normal activities held on athletic fields. Color shall be standard field green as approved by owner/representative.
- c. Turf shall surpass 200,000 Lisport Cycles as certified by a 3rd party independent testing agency.
- d. Provide tufted and inlaid markings where required per drawings installed in accordance with the manufacturer's recommendations. Lines shall be tufted within the 15-foot wide rolls to the maximum extent possible.
 - 1) White for football markings.
 - 2) Blue for boys lacrosse, Red for girls lacrosse.
 - 3) Yellow/Gold for soccer markings.
- e. Provide Dimensional Stability layer in turf backing.
- f. Glued seams: Seaming tape and adhesive shall meet the approved synthetic turf manufacturer's requirements and minimum performance characteristics specified herein.
 - 1) Adhesives for bonding tufted synthetic turf shall be one-component fast-set urethane adhesive obtained from a single manufacturer and be equivalent to Ultrabond Turf PU 1K as manufactured by Mapei Corporation, Deerfield Beach, FL (800) 992-6273, or approved equal.
 - 2) Tape for securing seams in the tufted synthetic turf and inlaid lines shall be

high quality tape made with a minimum roll width of 12 inches.

D. Infill Material:

1. The composite infill shall be a homogeneous blend of sand and plant-based organic infill granules unless patents allow for other approved compositions.
2. BrockFill or Safeshell plant-based infills shall be combined at a ratio of 80% sand and 20% plant-based infill by weight with sand content between 4.5 to 5 lbs/SF or 18mm in depth. Corkonut by GreenPlay Organics LLC shall be combined at a rate of 66.7% sand to 33.3% plant-based infill by weight with sand content of 4 lbs/SF or 15mm in depth. Total depth of infill shall be a minimum 38 mm with a + tolerance of 4mm. Additional plant-based infill may be required to achieve infill depth requirements.
3. Sand shall be a 20-40 round to sub-round; dust-free, meeting the following Particle Size Distribution:

Sieve Size Mesh	Min % Retained	Max % Retained
8	0	0
10	0	0
12	0	0.1
14	0	0.5
16	0	15
20	10	60
30	10	90
40	0	40
50	0	5
60	0	0.5
70	0	0.5
100	0	0.5
pan	0	0.5
	Total – 50M	<1

- a. Krumbein #must be \geq to 0.4.
 - b. API Crush – 50M fines generation at 80 psig: \leq 0.4%.
4. Plant-based Organic infill shall be Brockfill by BrockUSA, Boulder, CO, or approved equal, locally represented by Eric Hughes tel 781-883-9663
- a. Alternate products: Safeshell by US Greentech, Cincinnati, OH tel 888-323-0721 or Corkonut by GreenPlay USA tel 516-223-0202
 - b. Material requirements
 1. 100% plant-based organic material free of pesticides and heavy metals by AOAC Method 2007.01
 2. Infill shall be manufactured from sustainably harvested sources.
 3. Vertical drainage that exceeds the synthetic turf product using ASTM 1551.
 4. Resistant to degradation in accordance with BS EN 933-1:2012. 80% shall fall between 0.8mm – 2mm.
 5. Hydrophilic, absorptive of rain and condensation.
 6. Min. bulk density of 15lbs/cu ft.
 7. Infill shall not float
 8. Shall provide a minimum 8-year warranty.

5. Total depth of infill shall be a minimum 1.26 inches in depth (72% of the fiber height), with a + tolerance or 1/8" only.

2.4 RESILIENT UNDERLAYMENT

1. Submittals:
 - a. Product Data: Submit 8" x 8" product sample and technical data sheet.
 - b. Shop Drawings: Submit cross-sectional view showing product installation in relation to sub-base and synthetic turf (including edge attachment).
 - c. Test Data: Submit listing of all applicable test data for compliance to specifications. All testing to be performed by independent sources following applicable ASTM or other internationally recognized standards and procedures.
 - d. Installation: Submit copy of product installation instructions. Submit copy turf installation recommendations.
 - e. Warranty: Submit copy of product 16 -Year warranty coverage.
2. Shall be SP-17™ by Brock® and as supplied by Brock International, Boulder CO 80301, (303) 544-5800, or approved equal. Additional acceptable expanded polypropylene shock pad products include these sources:
 - a. ShockWwave Ecobase, www.nottssport.co.uk
 - b. UltraBaseMAX, www.ultrabasesystems.com
3. Underlayment shall be 17 mm thick expanded polypropylene designed for athletic fields. Material thickness shall be based upon product thickness needed in order to meet the system performance requirements.
4. GMax shall be between 85-120 throughout warranty period and must not exceed 120 for the life of the turf/infill/pad system.
5. The complete synthetic turf system including shock shall meet minimum critical fall height of 1.4m per IRB Reg 22 and One Turf Concept at installation and throughout the warranty period. HIC not to exceed 1000 on pad from a 1.4m drop height of for the life of the system.
6. Product shall drain at greater than 300 inches per hour.
7. Warranty shall be 16 years or more and cover the cost to replace or repair the turf in affected area in the event of product failure. Warranty must guarantee the turf/pad system not to exceed 125 Gmax for the life of the turf with no less than 1" of infill.
8. Recycled expanded polypropylene content shall not exceed 30 percent.
9. When tested with the Deltec field tester, vertical deformation must remain between 7-11mm.
10. Supplier must provide documentation that product meets human health screening levels and total threshold limit concentration using EPA Method 3052 and Title 22 (CAM 17) metals using EPA Method 6020/7471A and for hexavalent chromium using EPA Method 7196A.

11. Manufacturer must prove absence of heavy metals in production material, and a controlled chain of custody for all materials used.
12. All material used in the artificial system must meet environmental and human health standards established in this specification. Documentation of chain of custody for materials may be required.
13. Product must be of a homogeneous material composition. Variable material content will not be accepted

2.5 SUBDRAINS AT TURF FIELD

- A. Furnished and installed under section 33 40 00 Storm Drainage.

2.6 SYNTHETIC TURF MAINTENANCE EQUIPMENT

- A. Provide one (1) Synthetic Sports Turf Groomer with integrated Spring Tine Rake for routine maintenance of the synthetic turf field. Maintenance equipment shall be Model# 920SDE as provided by GreensGroomer WorldWide, Inc. PO Box 34151, Indianapolis, IN 46234. 888-298-8852, or equal as approved by the Landscape Architect.
 1. Sports Turf Groomer shall be:
 - a. Towable product.
 - b. Constructed of steel tube with powdercoat finish.
 - c. Length shall be minimum of 48" and minimum width of 72".
 - d. Groomer shall have an electric lifting mechanism to lift the brushes and spring tines off the field surface.
 2. Spring Tine Rake Attachment shall be:
 - a. Attachable product compatible with the Turf Groomer product.
 - b. Frame shall be constructed of steel with powdercoated finish.
 - c. Width shall be minimum 72".
 - d. Tines shall be 3/16" diameter with a tip bend between 38-42 degrees.
 - e. Three (3) rows of tines with each row consisting of 12-14 tines. Tines shall be spaced 7/8" apart. Tines shall be offset from the other rows.
 - f. Each row shall be independently adjustable for depth and allowed to be set in a forward or backward position for various levels of aggressive raking.
 3. Rake attachment shall be able to fully retract the tines allowing the rake to remain attached to the groomer when not in use
- B. Provide one (1) LitterKat Synthetic Turf Sweeper with Tow-magnet as provided by GreensGroomer WorldWide, Inc. PO Box 34151, Indianapolis, IN 46234. 888-298-8852, or equal as approved by the Landscape Architect:
 1. Sports Turf Sweeper shall be:
 - a. Towable product.
 - b. Constructed of steel tube with powdercoat finish.
 - c. Width shall be a minimum of 72".
 - d. Sweeper shall be direct drive gear drive.
 - e. Debris basket shall be removable.
 - f. Sweeper shall have an electric lifting actuator to lift basket and sweeping brush off the field surface.
 2. Magnet bar shall be:
 - a. Towable product.

- C. Width shall be minimum of 72" , depth of minimum 5" , height of 2" minimum

2.7 PASSIVE USE SYNTHETIC TURF.

- A. To establish the standard of quality, design, aesthetics and function desired, Drawings and Specifications are based on "SYNAugustine347" available from SYNLawN (www.synlawn.com) 55 Fulton St #100, Canton, MA 02021 Phone (781) 821-01112.
1. Additional acceptable manufacturers are noted below provided they meet the performance and aesthetics specifications of realistic looking lawn with multi-color blades:
 - a. X-Grass, parent company Challenger Industries, Dalton, GA. Tel 877-881-8477.
 - b. ForeverLawn, Louisville, OH Tel: 866 992 7876.
- B. Synthetic Turf must meet or exceed the following criteria and physical properties.
1. Grass Zone Yarn/Color - PE/Field Green/Olive/Apple.
 2. Grass Zone Denier - 10,800/6.
 3. Thatch Zone/Yarn/Color - PE/Field Green/Beige.
 4. Thatch Zone Denier - 5,000/8.
 5. Grass Zone Yarn Shape- Legend Mono.
 6. Finished Pile Height - 1".
 7. Finished Pile Weight - 58 oz.
 8. Backing - 15/18 PP 2-Part/22oz Enviro.Loc.
 9. Tuft Gauge - 3/8".
 10. Tuft Bind - > 8 lbs.
 11. Permeability - > 400 inches per/SY.
 12. Features - Sanitized, EnvironLoc, StatBlock, Anti-static, DualChill IR Reflective, Deluster, UV Stabilizers.
 13. Test Data - ASTM E108 Class A Fire Rating, F1292, F1951, IPEMA Certified.
- C. Glued seams: Seaming tape and adhesive shall meet the approved synthetic turf manufacturer's requirements and minimum performance characteristics specified herein.
1. Adhesives for bonding tufted synthetic turf shall be two-component fast-set urethane adhesive obtained from a single manufacturer and be equivalent to Ultrabond Turf PU 2K as manufactured by Mapei Corporation, Deerfield Beach, FL (800) 992-6273, or one-part moisture-cured polyurethane obtained from a single manufacturer and be equivalent to 34-G as manufactured by Synthetic Surfaces, Inc., Scotch Plains, NJ (908) 233-6803, or approved equal.
 2. Tape for securing seams in the tufted synthetic turf and inlaid lines shall be high quality tape made with a minimum roll width of 12 inches.
- D. Infill –Sand shall meet the material requirements specified within this Section 321823.
- E. Turf anchor shall be as described on the Landscape Drawings.
- F. Roof deck waterproof membrane as furnished and installed under Section 0754000 Thermo-plastic Membrane Roofing.

PART 3 – EXECUTION

3.1 COORDINATION

- A. The work of this Section shall be performed in full compliance with all approved submittals and certifications, and in conformance with the approved manufacturer's recommendations and requirements.

- B. The synthetic turf manufacturer's representative shall inspect all adjacent site conditions and verify that they are in proper condition to receive the work described within this Section. Notify the Engineer of any condition that may potentially affect proper execution of the work. Beginning work of this Section means acceptance of existing substrate surfaces and site conditions.

3.2 SUBGRADE

- A. Fine grade existing subgrade in accordance with the approved manufacturer's requirements. Upon completion of fine grading, the contractor shall measure the subgrade elevations with a laser level at a minimum of 100 evenly spaced points throughout the field area. Written approval of the subgrade elevations by the manufacturer's representative is required prior to placement of geotextile and drainage base materials.

3.3 GEOTEXTILE FILTER FABRIC

- A. Geotextile filter fabric shall be placed over the entire surface of the approved subgrade, including under the sub drains. Overlap joints a minimum of twelve (12) inches. Prevent any soil contamination of the underdrains to provide a clean connection to the drainage layer under the synthetic turf field.

3.4 DRAINAGE STONE & SUBDRAINS

- A. Install the sub drains within the bottom drainage layer as indicated on the Drawings. Bottom and top layers of drainage materials meeting the manufacturer's engineered criteria for this project, shall be placed and compacted in accordance with the manufacturer's installation requirements. A minimum of two (2) separate layers of drainage materials placement will be required.
- B. Drainage stone shall be placed as per requirements of Section 312000 Earth Moving. To prevent segregation of different aggregate sizes handling of the base stone material shall be minimized. The finished surface of the top drainage stone layer shall be fine graded in preparation of measurement. The contractor shall measure the top drainage stone layer at a minimum of 100 evenly spaced points throughout the field area with a laser level to attain the required elevations. Surface tolerance shall not exceed 3/16 inch in ten feet. Infiltration of the Drainage Stone shall be no less than 40 inches per hour (40"/hr) or as noted with Section 31200 Earth Moving, whichever is greater. Written approval of the drainage base by the manufacturer's representative is required prior to installation of the synthetic turf system.
- C. Placing, Spreading and Compacting Base Stone Material at Synthetic Turf Field:
 - 1. Fill materials are to be placed as designated herein and as indicated on the Contract Drawings.
 - 2. Base Stone shall be placed as follows and compacted as specified herein: As a base course, compacted subgrade, as shown on the Drawings.
 - 3. Finishing Top Stone shall be placed as follows and compacted as specified herein: Finishing Stone shall be 1" compacted depth above Base Stone as shown on the Drawings.
 - 4. After each layer has been placed, it shall be thoroughly compacted to the specified density. Compaction shall be continuous over the entire area and the equipment shall make sufficient passes to ensure that the desired density is obtained. A minimum of four coverage's with acceptable compaction equipment is a requirement.

3.5 COMPACTION

- A. Compaction Requirements: The degree of compaction as shown on the drawings shall be in accordance with section 312000 Earth Moving

1. Laser grading shall be used in the construction of the stone base material for the Synthetic Turf fields.
- B. The contractor shall provide base stone and top stone testing by a 3rd party for infiltration, planarity and compaction by an approved testing agency specializing in synthetic turf fields.

3.6 SHOCK PAD

- A. Protect the shock pad material from direct exposure to sunlight during storage.
- B. Install the shock pad in strict accordance with the manufacturer's recommendations. Shock pad installation shall be completed by the Synthetic Turf Installer and/or by a contractor certified by the approved shock pad manufacturer. An official representative from the shock pad manufacturer shall be present on the site at the commencement of the installation.
- C. The synthetic turf and shock pad shall be installed simultaneously. In order to reduce movement or damage, the shock pad shall only be installed as far ahead as 2 turf rolls and shall be completely covered at the end of each work day.
- D. As the infill is placed in on top of the turf, secure the shock pad to avoid shifting movement of line markings. Replace or reposition any panels that are shifted or damaged.

3.7 SYNTHETIC TURF SYSTEM

- A. The accepted synthetic turf system shall be installed in accordance with the manufacturer's requirements and in coordination with the manufacturer's representative such that the manufacturer will certify the acceptability of the installation from subgrade to the finished synthetic turf system in writing.
- B. Provide all materials, labor and equipment necessary to perform turf installation including, but not limited to, water and rollers to maintain stability and planarity of approved base.
- C. Attach the synthetic turf to the perimeter edge detail in accordance with the manufacturer's recommendations.
- D. After a final inspection of the prepared base by the Field Builder and the Owner's Representative, the synthetic turf installation shall begin. The first roll shall begin with the longest perpendicular cross-field distance. Pile lay shall be in accordance with the approved shop drawings. No head seams shall be permitted.
 1. All visible wrinkles shall be stretched out before seaming.
 2. Seams shall be flat, tight and permanent with no separation or fraying.
- E. Seams shall be glued without bulging in the backing material. Visible seems in the finished installation are not acceptable. Seaming tape shall extend a minimum of 6" in all directions from any material joint.
- F. The adhesive shall extend at it's full application rate a minimum of 4" in all directions from any material joint.
- G. The adhesive shall be applied at the adhesive manufacturers' recommended application rate at 99% efficiency.
- H. All seams shall have a min. grab tear strength of 150 lbs and 5% elongation based on ASTM D5034-05.
- I. When all rolls of the playing surface have been installed, the sideline areas shall be installed perpendicular to the playing field.
- J. Install inlaid field markings to complete the tufted markings for football, and lacrosse

layouts and tick marks at soccer in accordance with the approved shop drawings and applicable standards.

- K. After all seaming and inlaid markings are complete, the plant-based and sand infill shall be spread evenly using a drop spreader or topdresser in accordance with the manufacturers' recommendations.
 - 1. Infill shall be applied in a uniform rate of multiple applications until the required infill depth is achieved.
 - 2. Infill material shall be brushed between infill applications with a motorized rotary broom and pull-type groomer brush simultaneously. Apply layers with a stiff bristle broom to stand fibers up and allow infill to settle into the bottom.
 - 3. A minimum infill rate of 6 lbs. per square foot is required based on the ratio of plant-based infill to sand specified herein.
 - 4. Presence of wrinkles in the synthetic turf and evidence of inadequate ballast will require additional sand.
- L. Synthetic Turf Perimeter Attachment: After final trimming of the turf, the turf shall be attached to the curb in accordance with the manufacturer's recommendations using mechanical fasteners and adhesive. The edges shall be secure and have a neat and smooth transition to adjacent surfaces

3.8 PASSIVE USE SYNTHETIC TURF

- A. Install synthetic turf play lawn in accordance with these specifications, the drawings and the manufacturer's recommendations.
 - a. Verification of Conditions:
 - i. Confirm work by others is installed per the project requirements. Do not cover work by others prior to inspection or acceptance.
 - ii. Inspect seams, penetrations and details. Identify defects in writing to the Architect.
 - iii. Do not proceed until unacceptable conditions are corrected.
 - iv. After a final inspection of the prepared base by the Owner's Representative, the synthetic turf installation shall begin.
 - b. Protection mat/separation membrane:
 - i. Install the Protection Mat above a waterproofing membrane (by-others) with an overlap of 4.0 inch. Cut the protection mat in situ at roof penetrations. Consider an allowance for overlap and wastage of approx. 10–15%.
 - c. Provide all site preparation required to install turf.
 - d. The accepted synthetic turf system shall be installed in accordance with the manufacturer's requirements and in coordination with the manufacturer's representative such that the manufacturer will certify the acceptability of the installation from roofing membrane (by-others) to the finished synthetic turf system in writing.
 - e. Provide all materials, labor and equipment necessary to perform turf installation.
 - f. All visible wrinkles shall be stretched out before seaming.
 - g. Seams shall be flat, tight and permanent with no separation or fraying.

- h. Seams shall be glued without bulging in the backing material. Visible seams in the finished installation are not acceptable. Seaming tape shall extend a minimum of 6" in all directions from any material joint.
- i. The adhesive shall extend at its full application rate a minimum of 4" in all directions from any material joint.
- j. The adhesive shall be applied at the adhesive manufacturers' recommended application rate at 99% efficiency.
- k. After all seaming and inlaid markings are complete, sand infill shall be spread evenly using a drop spreader or topdresser in accordance with the manufacturers' recommendations.
 - i. Infill shall be applied in a uniform rate of multiple applications until the required infill depth is achieved.
 - ii. Infill material shall be brushed between infill applications with a motorized rotary broom and pull-type groomer brush simultaneously. Apply layers with a stiff bristle broom to stand fibers up and allow infill to settle into the bottom.
 - iii. A minimum infill rate of 5 lbs. per square foot is required.
 - iv. Presence of wrinkles in the synthetic turf and evidence of inadequate ballast will require additional sand.
- l. Synthetic Turf Perimeter Attachment: After final trimming of the turf, the turf shall be attached to the edger in accordance with the manufacturer's recommendations using mechanical fasteners. The edges shall be secure and have a neat and smooth transition to adjacent surfaces.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Prior to Owner acceptance of the synthetic turf installation, the Synthetic Turf Manufacturer/Installer shall engage an independent testing agency approved by the Landscape Architect to perform permeability, G-Max and HIC testing in accordance with the testing methods referenced herein and according to the Synthetic Turf Council's recommendations.
- B. Layout Verification: Prior to Owner acceptance of the synthetic turf installation, the Synthetic Turf Manufacturer/Installer shall engage a Professional Engineer or Registered Land Surveyor to verify the sizes and locations of the football and soccer field locations.
- C. Remove and replace or install additional materials as necessary where test results of measurements indicate non-conforming conditions to specified requirements or industry standards.

3.10 OWNER TRAINING

- A. Upon completion of the synthetic turf installation, the synthetic turf manufacturer/installer shall provide training in person for the proper care and maintenance of the synthetic turf system at up to two (2) meetings with the Owner's maintenance personnel. Provide submittals in accordance with Article 1.4 herein.

3.11 CLEANING, REPAIR AND PROTECTION

- A. The turf installation contractor shall provide all labor, materials and equipment for cleaning, repair

and protection of the installation to the satisfaction of the Landscape Architect.

- B. Within the first 3 months after final acceptance, the turf installation contractor shall replenish the specified infill material to the required depth at no additional cost to the Owner if the depth of the infill is found to have settled to be less than specified throughout the field surface during that timeframe.

3.12 CLOSEOUT

- A. The synthetic turf representative must verify that a qualified representative has inspected the installation and that the finished field surface conforms to the Manufacturer's requirements.
- B. The synthetic turf manufacturer shall provide the warranty, training and maintenance manual specified herein.
- C. Extra materials: Contractor shall leave specified attic stock, surplus turf pieces of usable size, additional sand and plant-based infill with the Owner.

END OF SECTION

SECTION 32 18 23.13

BASEBALL AND SOFTBALL FIELD SURFACING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 apply to the work of this Section.

1.02 DESCRIPTION OF WORK

- A. The work of this Section consists of providing all labor, equipment, materials, incidental work, and construction methods necessary to perform all lawns, plantings and related work as indicated on the Contract Documents and as specified in this Section and includes, but is not limited to, the following:
 - 1. Placement of Infield Mix and topdressing
 - 2. Construction of pitcher's mounds and batters boxes with mound clay
 - 3. Fine grading
 - 4. Inspection and acceptance
 - 5. Cleaning and protection
- B. Sustainable Building Requirements:
 - 1. The Contractor is to implement practices and procedures to meet the project's sustainable performance goals, which include achieving LEED v4 Silver certification based on USGBC's "LEED Version 4 for Building Design and Construction: Schools" (LEED v4 BD+C: Schools).
 - 2. The work of this Section includes responding to Architect or Contractor requests for additional information or product data and may be required following initial Green Building Certification Institute (GBCI) review of LEED Application.
 - 3. Product substitution requests are subject to additional LEED submittal requirements including, but not limited to, Environmental Product Declarations (EPD), Health Product Declarations (HPD), and General Emissions Testing.

1.03 RELATED WORK

- A. Carefully examine the site and all of the Contract Documents for requirements that affect the work of this Section. No claim for additional costs will be allowed because of lack of full knowledge of existing conditions. Other specifications sections that directly relate to the work of this Section include, but are not limited to, the following:
 - 1. Section 312000 Earth Moving
 - 2. Section 323100 Fencing
 - 3. Section 328400 Irrigation
 - 4. Section 329100 Loam and Planting Preparation
 - 5. Section 329200 Turf and Grasses
- B. The work of this Section shall be coordinated with that of other trades affecting, or affected by, this work, as necessary to assure the steady progress of all work of the Contract.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. D 75 Practice for Sampling Aggregates
2. D 422 Test Method for Particle-Size Analysis of Soils
3. D698-00a Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³)
4. D1557 Moisture-Density Relations of Soils and Soil-Aggregate Mixtures using 10-lb rammer and 18-in. drop
5. A.O.A.C. Association of Official Agricultural Chemists.

1.05 SUBMITTALS

- A. At least 30 days prior to ordering materials, the Contractor shall submit to the Architect representative samples, certifications, manufacturer's product data and certified test results for materials as specified below. No materials shall be ordered or delivered until the required submittals have been reviewed and approved by the Architect. Delivered materials shall closely match the approved samples. Approval shall not constitute final acceptance. The Architect reserves the right to reject, on or after delivery, any material that does not meet these Specifications.

1.06 REGULATORY REQUIREMENTS

- A. Strictly comply with all applicable codes, regulations and requirements having jurisdiction.

1.07 EXAMINATION OF CONDITIONS

- A. The Contractor and any sub-Contractor responsible for the execution of the Work of this Section, shall review the subgrades and elevations to verify that the subgrades have been prepared in accordance with the Contract Documents, prior to proceeding with the spreading of the planting loam. Carefully review the requirements of this Section, to understand the requirements of percolation testing, compaction, slope and absence of debris of the subgrade prior to spreading of the loam borrow.
- B. The Contractor shall be solely responsible for judging the full extent of work requirements involved, including but not limited to sampling and testing of all materials prior to final planting installation.

1.08 DEFINITIONS

- A. The following definitions shall apply to the work of this Section.

The following size distributions of mineral particles by diameter and sieve size shall apply to the following conventional names of soil types:

<u>Conventional Name</u>	<u>Retained on U.S. Sieve No.</u>	<u>Diameter (mm)</u>
Very coarse sand	#18	1 - 2
Coarse sand	#35	0.5 - 1
Medium sand	#60	0.25 - 0.5
Fine sand	#140	0.10 - 0.25
Very fine sand	#270	0.05 - 0.10
Silt	by hydrometer	0.002 - 0.05
Clay	by hydrometer	Less than 0.002

PART 2 - PRODUCTS

2.01 INFIELD MIX

A. Furnish and Install Infield Mix as shown on the drawings for the softball infields.

1. The basis of design of the Infield mix shall consist of a blend of Sand, Silt and Clay that is mechanically mixed offsite in a controlled environment using a pugmill-type mixer that ensures a complete and thorough blending of the sand, silt and clay to the specifications as outlined. Infield Mix material shall be Dura Edge - Classic as manufactured by DuraEdge Products, Inc., 149 South Broad Street, Grove City, PA, 16127, 866-867-0052, or approved equal.
2. Performance Specifications are as follows:
 - 1) Infield mix shall be clean, dry clay mixed with washed mason-type sand that is a reddish-brown color having a yield of 1.35 tons per cubic yard loose or 1.5 tons per cubic yard compacted to 85%-90% on a Standard Proctor Test (ASTM D 689-07). The material shall pose the following particle size analysis:
 - a) Total sand content shall be 70%-75%.
 - b) The combined amount of sand retained on the medium, coarse and very coarse sieves shall be greater than or equal to 50 percent (50%)
 - c) The combined amount of silt and clay shall be 25%-30%
 - d) The ratio of silt divided by clay, otherwise known as the SCR, shall be 0.5-1.0
 - e) No particles greater than 3mm are allowed
 - f) Equal to or less than 5 percent (5%) pf particles shall be retained on the 2mm sieve

2.02 INFIELD TOP DRESSING

A. Furnish and install topdressing at levels in accordance with the manufacturer's recommendation. Product shall be DuraEdge ProSlide by DuraEdge Products, Inc., Grove City, PA, 16127, 866-867-0052, or approved equal.

2.03 INFIELD MOUND CLAY FOR BATTER'S BOX AND PITCHERS MOUND

- A. Furnish and install mound clay product at the batter's box. Product shall be DuraPitch Premium Mound Clay by DuraEdge Products, Inc., Grove City, PA, 16127, 866-867-0052, or approved equal.
- B. Batter's box clay shall be clean dry clay mixed with mason sand.
 1. Sand content 15-28%
 2. Overall clay >30%
 3. Ratio of silt divided by clay shall be between.75-1.

PART 3 - EXECUTION

3.01 FILLING AND COMPACTION

A. Perform percolation tests on existing subsoils or placed fill prior to placing and spreading

loam for planting:

1. Perform percolation testing of subsoil or placed fills to determine whether or not the subgrade will drain properly. Perform percolation tests as specified in this Section.
 2. In the event that percolation testing indicates that the subsoil, placed fills or ordinary borrow has been over compacted and will not drain, the contractor shall loosen up the top 18 – 24” inches of the subgrade to be planted, seeded, or sodded by ripping or other mechanical means. Recompact the borrow by driving a small, tracked bulldozer over the area at low speeds so that the tracks of the bulldozer pass over the affected area and the soil is compacted to a density that will percolate as specified under the work of this Section. Under no circumstances shall wheeled vehicles be driven over subsoil, placed fills or ordinary borrow that have been shown to percolate or subsoil, placed fills or ordinary borrow that has been loosened and shown to percolate.
 3. Perform sufficient percolation tests in areas of poorly draining or compacted subsoil or compacted placed fills as directed by the Architect to ensure that these underlying soils drain. Likewise, perform sufficient percolation tests after ripping and loosening to ensure that the soils are no longer too compact to drain.
- B. Subsoil or ordinary borrow shall have been excavated and filled in accordance with the Contract Documents. Do not damage the work previously installed. Maintain all required angles of repose of materials adjacent to the loam as shown on the Contract Documents. Do not over excavate compacted subgrades of adjacent pavement or structures during loaming operations.
- C. Confirm that the compacted subgrade is at the proper elevation and that no further Earth Moving is required to bring the subgrade to proper elevations. Subgrade elevations shall slope parallel to the finished grade and or toward any subsurface drain lines as shown on the Contract Documents. Provide a written report to the Architect that the subgrade has been placed to the required elevations and that the subgrade drains water at the rates specified under the required percolation tests specified, performed and paid for under this Section, Loam and Planting Preparation. Perform no work of placing and spreading loam until elevations have been confirmed and written report has been accepted by the Architect.
- D. Clear the subgrade of all construction debris, trash, rubble and any foreign material. In the event that fuels, oils, concrete washout or other material harmful to plants have been spilled into the subgrade material, excavate the soil sufficiently to remove the harmful material. Such construction debris, trash, rubble and foreign material shall be removed from the site and disposed of in a legal manner. Fill any over excavation with approved fill and compact to the required subgrade compaction levels.
- E. Do not proceed with the installation of loam until all utility work in the area has been installed.
- F. Protect adjacent walls, walks and utilities from damage or staining by the loam. Use 0.5-inch plywood and or plastic sheeting to cover existing concrete, metal and masonry work and other items as directed during the progress of the work. Clean up all trash and any soil or dirt spilled on any paved surface at the end of each working day.

3.02 FINE GRADING

- A. Finish grades associated with the grading of the athletic field areas shall be performed with laser-guided grading equipment to meet the tolerances required by the Drawings and Specifications. Before spreading loam or infield mix material, the Contractor shall furnish and install grade stakes sufficiently spaced to insure correct line and grade of the finished subgrade. The Contractor shall verify elevations and do whatever additional grading is necessary to bring the subgrade layer to a true, smooth slope parallel to the finish grade for all areas to receive loam.

- B. Confirm that the final grade of the infield mix is at the proper finish grade elevations and flush with the soil surface of adjacent lawn areas. If necessary, adjust grade to meet the contours and spot elevations noted on the Plans. Request the presence of the Architect to inspect final grade. Do not proceed with the remaining work of this Contract until the Architect has given his/her written approval of the final grade.

3.03 INFIELD APPLICATION

- A. Installation of Infield Mix: Place material in lifts of 2"-3" and lightly compact until 85%-90% on the Standard Proctor Test (ASTM D 689-07). Scarify the surface to facilitate bonding of the next lift and repeat until finished grade is provided as indicated on the Drawings meeting adjacent turf areas with an even surface. Compaction factor is approximately 10%-15% per 1" of material. The infield shall be smoothly fine graded with a dual-planed laser grader
- B. Upon completion, the Contractor shall monitor, until final completion, the constructed infield to assure no migration between the proposed infield mix and surrounding loam. In any instance where loam migrated into the infield base paths, the Contractor must screen infield and remove loam.
- C. Top Dressing Infield: Provide finished grades as indicated on the Drawings meeting adjacent turf areas with an even surface. Blend top dressing mix into existing as recommended by manufacturer.
- D. Mound clay shall be placed in 2-inch lifts and compacted with a 1-ton vibratory roller to achieve optimum compaction of 90-95 percent. Scarify surface prior to placing next lift.

3.04 MAINTENANCE

- A. Skinned infield areas shall be maintained until adjacent lawn areas are accepted and turned over to the Owner. Maintenance shall include weekly scarification/grooming, filling in any low areas with approved mix to eliminate any puddling and cutting a crisp new lawn edge where infield mix meets lawn immediately prior to acceptance.

END OF SECTION

SECTION 321823.39
RESILIENT SPORT SURFACING

PART 1 - GENERAL

1.0 RELATED DOCUMENTS

This section is only a portion of the Contract Documents. All of the Contract Documents, including Conditions of the Contract and Division 1 General Requirements, apply to this section.

1.1 SPECIAL REQUIREMENTS / QUALIFICATIONS

- A. The resilient sport surface herein specified shall be installed by the surfacing Contractor's own forces having at least 10 years' experience including at least 12 successful outdoor synthetic track installations, and a crew supervisor with at least 6 successful surface installations of poured in place, two component elastomeric polyurethane synthetic track surfacing.
- B. The surfacing contractor shall be a certified track builder with the American Sports Builders Association.

1.2 DESCRIPTION OF WORK

- A. Provide all labor, materials equipment and services necessary to complete the work of this Section as specified herein and as shown on the Drawings.
 - 1. Installation of new 13mm (1/2") urethane-based permeable resilient sport surface on existing and new asphalt paving as shown on the Contract Documents and specified herein.
 - 2. Structural spray of track and field events.
 - 3. Measurement and Marking - Provide painted lane lines and associated markings for track and field events.
 - 4. Surface Guarantee.
 - 5. Clean up.
- B. Sustainable Building Requirements:
 - 1. The Contractor is to implement practices and procedures to meet the project's sustainable performance goals, which include achieving LEED v4 Silver certification based on USGBC's "LEED Version 4 for Building Design and Construction: Schools" (LEED v4 BD+C: Schools).
 - 2. The work of this Section includes responding to Architect or Contractor requests for additional information or product data and may be required following initial Green Building Certification Institute (GBCI) review of LEED Application.
 - 3. Product substitution requests are subject to additional LEED submittal requirements including, but not limited to, Environmental Product Declarations (EPD), Health Product Declarations (HPD), and General Emissions Testing.

1.3 RELATED WORK

- A. Carefully examine all of the Drawings and other Sections of the Specifications for requirements that affect, or are affected by the work of this Section. Other specification sections that directly relate to the work of this Section include, but are not limited to the following:
 - 1. Section 321200 – Asphalt Paving
 - 2. Section 323000 – Site Improvements
 - 3. Section 334000 – Storm Drainage Utilities

1.4 GUARANTEE

- A. Guarantee shall be a five (5) year unconditional guarantee from the manufacturer of workmanship and materials for the resilient sport surfacing from the date of acceptance. Track striping and markings shall be warranted for a period of thirty-six (36) months. During the guarantee period, the Contractor shall take all actions required to remedy to the Owner's satisfaction any deficiencies in the track surface.
- B. Resilient surfacing material found to be defective as a result of faulty workmanship and/or material failure shall be replaced or repaired at no cost to the Owner, upon written notification within the guarantee period.

1.5 SUBMITTALS

- A. Material certificates: Submit material certificates for all materials specified herein signed by material producer and Contractor stating that the materials are engineered and produced as a system for the specific purpose of exterior running track and field event resilient surface installations and that they are in compliance with the Contract Documents. Submit a copy of the manufacturer's unconditional workmanship and materials guarantee prior to ordering materials.
- B. Material samples: Submit samples of the material components for the resilient sport surface system, as well as a fully-assembled sample.
- C. Submit Certified Track Builder documentation provided by the ASBA. The installer must employ a certified track builder.
- D. Substrate acceptability: The Contractor shall submit a certified statement attesting that all surfaces to receive the resilient sport surfacing have been inspected and found satisfactory to receive the Work specified in this Section, and are not in conflict with Guarantee requirements.
- E. Submit shop drawing drawn to scale for all track and field event surface markings to be reviewed by the Owner for approval prior to any line or symbol marking.
- F. As-Built Survey: Upon substantial completion of the work, the Contractor shall submit an as-built survey performed by licensed professional land surveyor showing grades and dimensions as installed to verify compliance with the Contract Documents. The Contractor shall certify in writing that the installation is in compliance with NFHS and MIAA rules and regulations.
- G. Submit name and qualifications of the line striper.
- H. Submit name, contact and qualifications of the installer and a list of 15 track surface installations off this type within 100 miles.
- I. Final acceptance: Submit 3 copies of maintenance manuals, which include care and

maintenance of surface.

1.6 PROJECT CONDITIONS

- A. Weather: No part of construction shall be conducted during a rainfall or when rainfall is imminent. After rainfall sufficient time shall be given to allow the surface to dry before resuming work. Surface shall be dry and clean before beginning application and both ambient and materials temperatures shall be at least 50 degrees Fahrenheit and rising.
- B. Protection: Contractor shall provide all materials and labor necessary to completely protect adjacent materials and surfaces.

1.7 QUALITY ASSURANCE

- A. Resilient surface materials and installation shall be approved for NFHS & MIAA installations. Only track systems included in this Section are considered pre-approved.
- C. The completed track and field events shall conform to the guidelines of the NFHS and tolerances required by NFHS and MIAA regulations. All track and field event surfaces shall meet the material performance requirements set forth by the NFHS.
- D. Prior to work, a pre-installation meeting with installer, landscape architect and owner shall establish special requirements, sequence and methods.
- E. Prior to line striping, a meeting will be conducted to confirm all track markings.
- F. No part of the installation will be conducted during rainfall. Surface shall be thoroughly dry. Ambient temperature must be 50 degrees F and rising.

1.8 REFERENCES

- A. NFSH: National Federation of State High School Associations is the national governing body for high school competition.
- B. MIAA: Massachusetts Interscholastic Athletic Association is the state governing body for high school competition.
- C. ASBA: American Sports Builders Association

PART 2 - PRODUCTS

2.1 MATERIALS AND PRODUCTS

- A. All materials specified herein shall be part of a complete system developed specifically for the construction of a synthetic running track surface. All products shall be provided by one manufacturer.
- B. The resilient track surface shall be the BSS-100 Aliphatic Polyurethane system structural spray as manufactured by Beynon sports surfaces and installed by Cape and Islands Tennis and Track of Pocasset, MA tel 800-422-1827.
- C. Alternative Track Surface – Any alternative track surface paving system to be considered as an equivalent must be accompanied by certified test results based on IAAF test methods. Any product that is submitted with IAAF test results must include a stamped certification from the

testing laboratory that performed the tests. Material tests shall include, but are not limited to spike resistance and ultra-violet deterioration resistance. Pre-approved alternative systems that are substantially equivalent in material and performance to the Benyon BSS 100 system described herein are:

1. Action Track 200, provided by Copeland Coating Company, Inc. 3600 US Route 20, Nassau NY 12123 (518) 766-2932

D. Components for the polyurethane surface coating shall meet the following requirements;

1. Primer Shall be a polyurethane based primer specifically formulated to be compatible with the paved in place SBR granules and polyurethane track surfacing material.
2. Black SBR Granules Rubber granules for the base mate shall be recycled SBR rubber, processed and chopped to 1 -3mm, containing less than 1% dust.
3. EPDM Granules Rubber granules for structural spray wearing coats shall be EPDM synthetic rubber containing a minimum 20% EPDM resin, with a specific gravity of $1.5 \pm 0.1\text{g/cm}^3$. **The EPDM rubber color shall be BLACK.**
4. Binder Black mat binder shall be an MDI based single component polyurethane binding agent. The binder shall not have a free TDI monomer level above 0.2% and must be solvent free. The binder must be specifically formulated for compatibility with SBR crumb rubber.
5. Structural Spray Spray coating shall be an MDI based single component, moisture cured, 100% solids, pigmented polyurethane, and compatible with EPDM granules. **Coating shall be BLACK.** The spray coating shall be BEYPU 160 Waterborne Aliphatic Polyurethane Spray.
6. Line Paint The paint shall be a single component, moisture cured, aliphatic polyurethane paint compatible with the specified track surface material. All lane lines shall be white. All symbols shall be white with drop shadow.

PART 3 - EXECUTION

3.1 REPAIR

- A. Portions of the surface that are either weakened or have torn and delaminated shall be cut out and replaced with the polyurethane patching material
- B. Is strongly recommended the bidder perform a site visit prior to bidding to insure awareness of accurate repair scope.

3.2 CLEANING AND REPAIR

- A. Prior to application of additional layers of new material, the existing surface shall be cleaned of all loose dirt and debris. This includes weed treatment with an approved horticultural herbicide such as ECOsmart weed killer Test weed treatment in conspicuous area to ensure no staining or discoloration. Any area of the existing surface worn to the asphalt or delaminated shall be removed, surface cleaned, and repaired.

3.3 STRUCTURAL COATING APPLICATION

A, Apply in 2 layers of graded EPDM rubber particles with pre-pigmented polyurethane coating. Layers shall total 3.6 lbs per SY.

3.4 INSTALLATION OF NEW RESILIENT SURFACE

- A. Apply resilient sport surface to all areas indicated on the plans and details of the contract drawings. Install in strict accordance with the manufacturer's recommendations and instructions. Verify that the asphalt base is constructed properly prior to the installation of the resilient surfacing. Asphalt base shall be sound, free of voids and a uniformity of less than 3/16" deviations measured in any 10-foot direction.
- B. Finish surface preparation:
1. New asphalt surface shall be allowed to cure for a minimum of 21-days prior to installation of any resilient surface materials.
 2. Areas to be repaired shall be repaired so that the new material will properly bond to those surfaces. The surface must be thoroughly cleaned of all loose dirt and debris.
 3. Prior to the application of resilient surface materials, the entire surface shall be flooded and checked for minor depressions or irregularities. Areas that contain water covering a 1-inch diameter or larger shall be marked and repaired in accordance with the track surfacing manufacturer's recommendations. After corrective work, the asphalt surface shall not vary more than 1/8-inch in 10 feet, measured in any direction.
- C. After the asphalt base has been accepted and cleaned of all loose dirt and debris, apply the specified primer over the entire areas to receive the new resilient sport surface at a rate required as per manufacturers recommendations. A minimum of 30 minutes of curing time is required before application of the base mat material.
- D. Resilient Sport Surface
1. Shall be applied to achieve a dense uniform surface of no less than the specified thickness.
 2. The surface shall be applied to achieve the required thickness using a mechanically operated paver with heat-controlled screed for the base mat application.
 3. The base mat shall be allowed to cure thoroughly before structural spray application.
 4. The base bat shall be evenly distributed amongst the rubber granules upon the application of materials coverage rates (measured in accordance with I.A.A.F. standards).
 5. There should be no evidence of water present during the mixing process.
- E. Material disposition quantities for the Beynon BSS 100 track surface are as follows;
- Base Mat Course: The base mat shall consist of an 18-23% range polyurethane base mat binding agent and 77-82% range EPDM rubber base mat granulate.
- Wearing Course: EPDM rubber granules (0.5 to 1.5mm) shall be evenly mixed the specified single component structural spray coating. Structural spray shall be made in

a minimum of 2 uniform applications at a min. rate of 1.8lbs. per sq. yd., in opposite directions.

- F. Prior to the application of the final coatings and line marking, the surface shall be tested for the required surface depth, using a SMG-Sportplatzmaschinenbau GBMH surface depth gauge. The running track oval shall be tested in at least 12 locations along the center of the outer and inner lanes and along the center of the track. Average thickness of the track surface shall not be less than 12.7mm. Areas less than 10mm shall not exceed 10% of test locations. If the surface does not meet the required depth, additional layers of rubber and binder will be applied until the proper depth has been achieved.

3.2 MEASUREMENT AND MARKING

- A. Wait at least 48 hours after surface completion before applying line marking. The contractor shall supply all labor, materials and equipment necessary to perform the following:
1. No marking shall be performed without approved layout shop drawing. Refer to submittal requirements specified in this Section.
 2. Locate and establish all radius points without damaging field.
 3. Establish and set all necessary control points.
 4. Layout all lines and markings to within a 1/2" tolerance.
 5. Provide all computations and measurements in organized form.
 6. Establish all locations on the curves using a transit or Theodolite capable of reading direct to 20 seconds.
 7. Identify all markings, where appropriate, by painting the identification directly onto the track surface in 4-inch letters just below or in front of each mark in the right-hand portion of the lane.
 8. Paint all of the large, 3-foot-high lane numbers in two (2) colors, utilizing shadowed backgrounds and a sanserif font. Paint the name "GOLDEN KNIGHTS" with a sanserif font, within the third running lane on the home side straightaway on center of the field.
 9. All lines shall receive sufficient paint to assure complete opacity and uniformity of color.
 10. Paints shall be used directly from original containers and shall be thinned only when hot temperatures dictate thinning for smooth applications.
 11. Amount of paint used shall be as recommended by the manufacturer.
 12. All measurements shall be made by competent, experienced and fully qualified personnel.
 13. Upon completion of the track markings, a licensed professional engineer or registered professional land surveyor shall take the necessary measurements to certify the accuracy of the installation and markings. Refer to Item 1.5 SUBMITTALS, this Section.
 14. The markings shall include all events and marks required and recommended by MIAA and NFHS.

3.3 SURFACE GUARANTEE

A. Submit the following surface guarantee on the installation company's letterhead:

1. "(SURFACING CONTRACTOR) warrants the resilient surface at Northeast Metropolitan Regional Vocational High School for a period of Five (5) Years from date of acceptance against all defects in materials, including such defects as delamination, bubbling crackling, loss of integrity or excessive wear. (SURFACING CONTRACTOR) warrants that the lines and markings will be clearly legible for a period of 36 months. (SURFACING CONTRACTOR) will repair or replace any areas of the surface exhibiting defects at no cost to the Owner for the term of the guarantee."

3.4 CLEAN UP

- A. The Contractor shall remove all bags, pallets, plastic and any other items associated with the work of this Section and leave the site in clean, safe and finished condition.

END OF SECTION

SECTION 32 30 00
SITE IMPROVEMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. This section is only a portion of the Contract Documents. All of the Contract Documents, including Conditions of the Contract and Division 1 General Requirements, apply to this section.

1.02 DESCRIPTION OF WORK

- A. The work of this section includes, but is not limited, to the following:
1. Concrete Footings for all Site Improvement Items
 2. Grading and Compaction of Sub-Base
 3. Roof Courtyard Synthetic Tuff System
 4. Crushed Stone Mow Strip
 5. Flag Pole
 6. Contractor-Designed Segmental Retaining Wall
 7. Bottle Filling Station
 8. Fabricated Metal Railings
 9. Steel Vehicular Barrier Gate
 10. Electronic Gate
 11. Reclaimed Granite Seating Blocks
 12. Onsite Salvaged Landscape Boulders
 13. School Entrance Sign
 14. Cleaning, Repair and Protection
- B. The following items shown on the Drawings and/or noted herein shall be furnished under their Sections of the specifications:
1. Concrete filled steel bollards and fabricated handrails for stairs and ramps shall be furnished under Section 055000 METAL FABRICATIONS and installed under this Section 323000.
- C. Sustainable Building Requirements:
1. The Contractor is to implement practices and procedures to meet the project's sustainable performance goals, which include achieving LEED v4 Silver certification based on USGBC's "LEED Version 4 for Building Design and Construction: Schools" (LEED v4 BD+C: Schools).
 2. The work of this Section includes responding to Architect or Contractor requests for additional information or product data and may be required following initial Green Building Certification Institute (GBCI) review of LEED Application.
 3. Product substitution requests are subject to additional LEED submittal requirements

including, but not limited to, Environmental Product Declarations (EPD), Health Product Declarations (HPD), and General Emissions Testing.

1.03 RELATED WORK

- A. Carefully examine all the Contract Documents for requirements that affect the work of this Section. Other specification sections that directly relate to the work of this Section include, but are not limited to the following:
 - 1. Section 012300 - Alternates
 - 2. Section 116833 – Athletic Field Equipment
 - 3. Section 311000 – Site Clearing and Preparation
 - 4. Section 312000 – Earthwork
 - 5. Section 321313 – Concrete Paving
 - 6. Section 321200 - Asphalt Paving
 - 7. Section 321823.13 –Softball Field Surfacing
 - 8. Section 323100 - Fencing
 - 9. Section 329100 – Loam and Planting Preparation
 - 10. Section 323300 – Site Furnishings
 - 11. Section 323413 – Pedestrian Bridges
 - 12. Section 334000 - Storm Drainage Utilities

1.04 SUBMITTALS

- A. Shop Drawings: Refer to individual site improvements for submittal requirements.
- B. Provide manufacturer's product material information and system performance data along with material and system samples for each item specified in this Section for the Architect's review and approval prior to ordering materials.
- C. The General Contractor shall verify by field inspection that all items within this section conform to the specified requirements and approved submittals prior to installation.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials and products and provide adequate protection against damage. Handle in strict compliance with manufacturer instructions and recommendations and store off the ground. Protect from all possible damage including, but not limited to chipping, staining, cracking and other damage. Sequence deliveries to avoid delays but minimize on-site storage.

1.06 COORDINATION

- A. The work of this Section shall be coordinated with that of other trades affecting, or affected by, this work as necessary to assure the steady progress of the work of this Contract.
- B. Substrates: Proceed with work only when substrate construction and penetrating work is complete.

1.07 GUARANTEE

- A. In addition to the specific guarantee requirements of the GENERAL CONDITIONS and SUPPLEMENTARY GENERAL CONDITIONS, the Contractor shall provide the manufacturers' standard written warranty for each product within this specification. All of these guarantees shall be in addition to, and not in lieu of, other liabilities that the Contractor may have by law or other provisions of the Contract Documents.

PART 2 - PRODUCTS AND EXECUTION (Combined)

2.01 CONCRETE FOOTINGS FOR SITE IMPROVEMENT ITEMS

- A. Construct concrete footings as indicated on the Drawings.
- B. Concrete for footings shall have 28-day compressive strength of 5,000 PSI as specified in Section 321313 Exterior Concrete.
- C. Place concrete on moist subgrade or against prepared footings in continuous operation between transverse joints or individual sections. Vibrate all concrete. Do not place concrete in freezing temperatures or on frozen base

2.02 GRADING AND COMPACTION OF SUB-BASE

- A. Do all necessary grading in addition to that specified under Section 312000 - EARTHWORK to bring subgrade or foundation after final compaction to required grades and sections to obtain a foundation of uniform bearing surface. In absence of specific requirements, compact foundation by such means as shall provide firm base and insurance against settlement of superimposed work.
- B. Sub-base preparation, including material, shall be of properly approved quality as specified under Section 312000 - EARTHWORK. Start of work under this Section shall constitute acceptance of the foundation conditions to which this work is to be applied. Any defects in work resulting from such conditions shall be corrected under this Section 323000, Site Improvements, at no additional cost to the Owner.

2.03 ROOF COURTYARD SYNTHETIC TURF SYSTEM

- A. Basis of Design is "SynLawn Roof Premium" by Altantic Sports Group (www.atlanticsg.com)
Contact: Scott Koesterich (scott@atlanticsg.com) Ph: 781 821 0112
- B. Refer to the details for the sublayer profile but the turf will be installed directly over the roof membrane and follow the roof membrane pitch for the drainage
- C. The synthetic turf must meet ASTM E-108 Class A Fire Rating
- D. The specs for the SynLawn Roof Premium is as shown below

SKU	SAX47_ROOF
Grass Zone Yarn/Color	PE / Field Green / Olive / Apple
Grass Zone Denier	9,900 / 9
Thatch Zone Yarn/Color	PE / Field Green / Beige
Thatch Zone Denier	5,000 / 8
Grass Zone Yarn Shape	Soft Omega
Finished Pile Height	1 5/8"
Finished Pile Weight	100 oz.
Backing	13PP/18PET 2pt / 22oz. EnviroLoc+™
Tuft Gauge	3/8"
Total Weight	128 oz.
Tuft Bind	> 8 lbs.
Permeability	> 1,000 inches p/hr
Features	Sanitized*, EnviroLoc+™, StatBlock™ Anti-Static, DualChill™ IR Reflective, Deluster, UV Stabilizers
Test Data	ASTM E108 CLASS A FIRE, D2859, E648, F1292, F1551, F1951, CAL 1350, PFA-FREE

2.04 RAFFIC AND PARKING SIGNS

- A. Provide highest quality 3M Scotchlite (or approved equal) on aluminum traffic signs. Sign backgrounds, legends and borders shall be fabricated from high-intensity encapsulated lens

reflective sheeting conforming to the Massachusetts Department of Transportation's Standard Specifications for Highways and Bridges and the Manual on Uniform Traffic Control Devices (MUTCD), latest editions. Provide signs with the following characteristics, and per Signage Legend on the Drawings:

1. Mounting: Tamperproof stainless steel bolted fasteners to 12-gauge galvanized steel 2" square posts, except where shown mounted to light poles or otherwise noted on plan. Final locations to be determined in field. Mounting height shall conform to MUTCD standards. Concrete footings per Contract Documents.
2. Sign panels shall be 16-gauge aluminum panels. Sizes, color and copy as indicated on the Drawings.
3. Lettering and symbols shall be surface applied 3M Scotchlite reflective vinyl material Series #580 or approved equal. All lettering shall be executed in such manner that all edges and corners of the letterforms are true, clean, correctly spaced, and photographically precise. All lettering and graphics must accurately reproduce the letterform. Colors shall be consistent with highway standards.
4. Letterform meeting referenced standards. Where no standard exists, letterform shall be as selected by the Architect.
5. Provide shop drawing submittal for those signs with no MUTCD code.

2.05 CRUSHED STONE

- A. Shall consist of inert materials that are hard and durable, with stone free from surface coatings and deleterious materials.
- B. 1-1/2" fractured granite, light gray to dark gray in color.

2.05 FLAG POLE

- A. Submit complete and detailed shop drawings indicating entire flagpole, installation, foundation and all accessories.
- B. Furnish and install flagpole of 40 feet high in the location indicated in the Drawings.
- C. Flagpole shall be Model No.EC40IH as manufactured by Eder Manufacturing, Oak Creek, WI; Phone: (414) 764-3522 or one of the following approved equals:
 - a. Model LIB-ESR40C81 as manufactured by Liberty Flagpoles, Inc. (<https://www.libertyflagpoles.com>)
 - b. Model ESR40C82 as manufactured by Colonial Flag, Inc. (<https://www.colonialflag.com>)
- C. Finish to be brushed satin aluminum finish with internal halyard and stainless steel cable assembly.
- D. Flash Collar: Spun aluminum ground collar and ground sleeve for height of pole specified.
- E. Shim blocks shall be pressure treated hardwood wedges at top of foundation tube to adjust pole and maintain true vertical position. Lightning Protection: 3/4 inch diameter steel lightning protector ground spike welded to base plate and to support plate.
- F. Installation: Coordinate flagpole up lighting, refer to Electrical drawings. Install flagpoles in accordance with the manufacturer recommendations and approved shop drawings. Set flagpoles plumb and true and firmly wedged into foundation sleeve in the locations indicated on the Drawings. Install all parts and accessories such that the flagpole shall be in fully functional and proper operating condition.
- G. Furnish and install (1) 10x15 heavy Duty American flag of woven 2 ply polyester at 40' flagpole.

Made in the USA.

2.06 CONTRACTOR DESIGNED SEGMENTAL RETAINING WALL

- A. Work shall consist of furnishing all materials, labor, equipment and supervision to install the segmental retaining wall system in accordance with plans and specifications and in conformity with the lines, grades, design and dimensions shown on the Drawings. Retaining walls for this project include geogrid reinforced segmental retaining wall systems and gravity segmental retaining walls without geogrid at locations indicated on the drawings.
- B. Reference Standards
 - 1. Definitions and reference standards which govern the performance of the work in this Section include, but are not limited to the following:
 - 1) Current edition of the Massachusetts State Building Code (Code).
 - 2) OSHA Regulations, 29 CFR Part 1926.
 - 3) ACI Standard Building Code Requirements for Reinforced Concrete (ACI-318).
 - 4) National Concrete Masonry Association (NCMA) Segmental Retaining Walls Best Practice Guide, Revised 2016.
 - 5) Each manufacturer's respective Proprietary Wall System's specific precast concrete (or other proprietary specific material types) module, bin, segmental block and specifications.
 - 6) Each manufacturer's respective Proprietary Wall System's specific soil reinforcement reference standards and specifications.
 - 2. Segmental Retaining Wall (SRW) Units
 - 1) ASTM C 140 - Sampling and Testing Concrete Masonry Units
 - 2) ASTM C 1776 – Standard Specification for Wet-Cast Segmental Retaining Wall Units
 - 3. Geosynthetic Reinforcement
 - 1) ASTM D 4595 – Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
 - 2) ASTM D 5262 – Standard Test Method for Evaluating the Unconfined Creep and Creep Rupture Behavior of Geosynthetics
 - 3) ASTM D 5321 – Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic by Direct Shear Method
 - 4) ASTM D 5818 – Standard Practice for Exposure and Retrieval of Samples to Evaluate Installation Damage of Geosynthetics
 - 5) ASTM D 6706 – Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil
 - 4. Engineering Design
 - 1) "NCMA Design Manual for Segmental Retaining Walls," Third Edition
- C. Segmental Wall Design Criteria
 - 1. The approved wall system(s) and foundation shall be designed to function as a unit with the backfill behind and/or within the structural elements of the wall and shall form, when erected, a permanent retaining wall system capable of resisting applied forces without undergoing deformations or settlements which will unduly affect the

performance or appearance of the wall or result in loss of ground or damage to adjacent property or structures.

2. The approved wall system(s) shall be designed to resist all of the various (where applicable) lateral earth pressures including, but not limited to, conditions of the proposed ground surface levels and elevation differences (including sloping backfill), loads from compaction equipment, vehicular traffic, and seismic earthquake pressures per Section 1610.2 of the Code. Additionally, walls adjacent to fencing or netting should be designed to resist wind loads associated with these improvements.
3. The loads from compaction equipment include using a vibratory plate compactor weighing less than 300 pounds within 5 feet of back of the walls and a vibratory double drum compactor no larger than 2.5 tons operating weight with outside edge of the drum roller no closer than 5 feet from the walls.
4. The design must include an evaluation of global stability assuming retained soil parameters and subgrade soils presented as follows:

Soil Type	Minimum Unit Weight (pcf)	Maximum Friction Angle (degrees)
Retained Fill	135	32
Soil in Reinforced Zone	135	34
Subgrade Soils	125	34

5. The minimum factor of safety for global stability calculations shall be 1.5 under static conditions for the proposed retaining wall wherever its retained height is 8 feet or greater. For these walls, the minimum dimensions of the reinforced zone stated in the table below shall be used for the design. For other retaining walls, the minimum factor of safety for global stability calculations shall be 1.3.

Height Range (feet)	Minimum Benching Distance (feet)
10 – 14	14
8 – 10	10
0 – 8	No minimum benching distance required for global stability

6. The minimum lateral earth pressure shall be 250 pounds per square-foot (psf). The walls shall be designed to support post-construction surcharge loading of 250 psf at the ground surface, or construction loadings as required by the Contractor's operations, whichever is greater. Stability computations shall be made neglecting passive earth pressure in front of the retaining wall. The minimum factor of safety against overturning shall be 1.5, and the minimum factor of safety against sliding shall be 1.5 under static conditions.
7. Allowable stress criteria and design and analysis procedures shall be in conformance with the latest edition of the manufacturer's respective specification for their wall systems. The wall material shall, as a minimum, be designed to support lateral pressures computed from earth pressure, surcharge loads, compaction equipment and seismic earthquake pressures determined by using the design criteria shown on the Contract Drawings and as specified herein.
8. A maximum allowable design bearing pressure of 1 ksf shall be used.
9. The maximum design friction angle between the soil and the back of the retaining wall shall be 20 degrees.

D. Segmental Retaining Wall Submittals

1. Materials Submittals: The Contractor shall submit manufacturers' certifications stating that the SRW units meet the material requirements of this specification. Submit the manufacturer's product information and technical data for the block units, masonry adhesive, drainage materials and installation recommendations.
2. Samples: The Contractor shall provide samples of at least one in-line block, one corner block and one cap stone representative of the full range of color variations.
3. Submit for review and comment at least 21 days prior to delivery of retaining wall materials to the Site and prior to the start of Site retaining wall construction the following:
 - 1) Experience
 - a) Provide at least three (3) examples of segmental retaining walls successfully constructed by the Contractor. Examples shall be of similar type, height and length and be constructed in similar soil conditions. Provide Owner's name and telephone number for each example.
 - b) Provide documentation that Contractor's Engineer has at least five (5) years' experience designing selected wall types under similar conditions. Provide references for at least three (3) projects.
 - 2) Permanent Retaining Wall System(s)
 - a) A complete set of design calculations and shop drawings which shall include, but not be limited to, the following items for the Site Retaining Walls:
 - a. Legible, complete, and organized design computations indicating soil parameters, design criteria, pressure diagrams, allowable stresses, stability computations, and other details necessary to clearly demonstrate the rational basis for design.
 - b. Drawings showing all material specifications and details for the structural elements and sequences of assembly including backfilling materials and procedures.
 - c. The Site retaining walls shall be shown in plan, elevation, and section.
 - d. The elevation and location of any structure or utilities affecting or affected by any retaining wall shall be shown in plan and section.
 - e. Detailed construction procedures and sequencing for the installation of the retaining wall system shall be provided.
 - f. Details of drainage provided behind wall and connection of drainage to on site storm drains, as appropriate.
 - g. Calculations documenting internal and global stability. Calculations should include special conditions such as included utilities, guard rails and railings.
 - h. Drawings and computations shall bear the stamp and signature of a Professional Engineer who is licensed in the Commonwealth of Massachusetts and who is experienced in the design of retaining walls of the type proposed.
 - i. Latest edition of manufacturer's standards and specifications for proposed materials, method of installation, and list of material proposed for use.
 - j. Detail of fence post installation in or near top of wall.

1. The Contractor shall remain solely responsible for the wall design and the adequacy and safety of materials and methods used in construction.

E. Delivery, Storage and Handling

1. Contractor shall check materials upon delivery to ensure that the specified type and grade of materials have been received and proper color and texture of SRW units have been received.
2. Contractor shall store and handle materials in accordance with manufacturer's recommendations and in a manner to prevent deterioration or damage due to moisture, temperature changes, contaminants, corrosion, breaking, chipping or other causes.
3. Contractor shall prevent mud, wet concrete, epoxies and other deleterious materials from coming in contact with materials.
4. Contractor shall protect materials from damage; no damaged material shall be incorporated into the segmental wall.
5. Geosynthetic materials shall be protected from UV exposure and the protective covering on geosynthetic shall remain until immediately before installation and shall be stored at temperatures above -10 degrees F.

F. Quality Control

1. The Contractor is responsible for ensuring that construction adjacent to the wall does not disturb the wall or place temporary construction loads on the wall that exceed design loads, including loads such as water pressure, temporary grades, or equipment loading. Heavy paving or grading equipment shall be kept a minimum of 3 feet behind the back of the wall face. Equipment with wheel loads in excess of 150 psf live load shall not be operated within 10 feet of the face of the retaining wall during construction adjacent to the wall. Care should be taken by the Contractor to ensure water runoff is directed away from the wall structure until final grading and surface drainage collection systems are completed.

G. Materials

1. Segmental Retaining Wall (SRW) Units
 - 1) The basis of design SRW units shall be LedgeStone in New England color with 2-color color hardener as produced by Redi-Rock and represented by Casey Scavone, 617-620-1667, or approved equal. Portland cement concrete blocks specifically designed for reinforced retaining wall application.
 - 2) The concrete wall modules shall be 18 x 46 x 28 inches with a maximum tolerance of plus or minus 1/8 in. for each dimension. The retaining wall modules shall be solid units and have a minimum weight of 1520 lbs. per unit. The concrete wall modules shall have an integral shear key connection that shall be offset to permit a minimum wall batter of 5.2 degrees.
 - 3) Acceptable other manufacturers with products that conform to the details required for this project are:
 - a) Stone Strong Systems, Fractured Ledge finish 877-501-5652.
 - b) Recon Retaining Walls, Weathered Edge finish 800-696-7432
 - 4) The concrete wall modules shall have a minimum 28-day compressive strength of 4000 psi as tested in accordance with ASTM C 140 with an air entrainment of 6% +/- 1.5%.

2. Color of SRW units shall be selected by the Landscape Architect from the approved manufacturer's standard colors. The basis of design Redi-Rock LedgeStone shall have 2-color color hardener applied to the form surface for entire wall block faces. Approved equals that are unable to incorporate color hardener in their manufacturing process shall incorporate approved color admixture within the mix and use approved masonry stain in a random pattern after installation to be equal to Redi-Rock New England LedgeStone.
3. Sacrificial Anti-Graffiti Coating shall be Graffiti Seal manufactured by ChemMasters Specialty Construction Projects 300 Edwards Street, Madison, Ohio 44057, 800-486-7866, www.chemmasters.net or approved equal.
4. SRW unit faces shall be of straight geometry.
5. SRW units shall provide a minimum weight of 120 psf wall face area.
6. SRW units shall be capable of being erected with the horizontal gap between adjacent units at the units' front faces not exceeding 1/8 inch.
7. SRW units shall be sound and free of cracks or other defects that would interfere with the proper placing of the unit or significantly impair the strength or permanence of the structure. Any cracks or chips observed during construction shall fall within the guidelines outlined in ASTM C 1372.
8. SRW units' molded dimensions shall not differ more than + 1/8 inch from that specified, as measured in accordance with ASTM C 140. This tolerance does not apply to architectural surfaces, such as split faces.
9. Wall cap adhesive shall be a flexible, high-strength concrete adhesive in accordance with the wall manufacturer's recommendations.
10. Retaining wall shall allow coring and direct embedment of fence posts in top of wall.
11. Refer to Section 312000 - Earthwork for leveling pad, drainage aggregate, reinforced soil backfill and Geotextile filter materials.
12. Earth materials shall satisfy the requirements of the respective proprietary Retaining Wall System design. At a minimum, 3/4-Inch Crushed Stone shall be provided for a 1-foot-wide zone behind the wall to aid in drainage of the wall. In addition, all backfill shall meet the gradation criteria for On-Site Processed Fill (provided the fill contains less than 10 percent silt) or Gravel Borrow, as defined in Section 312000. Fill within the geogrid reinforcing zone shall be compacted to at least 95 percent of maximum dry density as defined by the Modified Proctor density test, ASTM D 1557, or higher if required by the respective proprietary retaining wall system design. It is anticipated that the on-site historic tunnel cuttings fill will need to be processed by crushing, as described in Section 312000, for wall backfill.
13. Refer to Section 334000 Storm Drainage Utilities for drainage pipe.

H. Installation

1. The Contractor shall contact DIG-SAFE at 1-888-344-7233 prior to commencing any excavation work at the site. Contractor shall verify location of existing structures and utilities prior to excavation. Contractor shall ensure all surrounding structures are protected from the effects of wall excavation. Excavation support, if required, is the responsibility of the Contractor.
2. Contractor shall excavate to the lines and grades shown on the project grading plans taking care to preserve the undisturbed state of the subgrade.
3. Following the excavation, the foundation soil shall be examined by the Owner's Engineer to assure actual foundation soil strength meets or exceeds the assumed

- design bearing strength. Soils not meeting the required strength shall be removed and replaced with compacted Gravel Borrow.
4. Foundation soil shall be proof-rolled and inspected by the Owner's Geotechnical Engineer prior to placement of leveling pad materials.
 5. Leveling pad shall be placed as shown on the final, P.E.-sealed retaining wall plans with a minimum thickness of 12 inches. The leveling pad shall extend laterally at least a distance of 12 inches from the toe and heel of the lowermost SRW unit.
 6. 3/4-Inch Crushed Stone leveling pad material shall be compacted to provide a firm, level bearing surface on which to place the first course of units. Well-graded sand can be used to smooth the top 1/4 inch to 1/2 inch of the leveling pad. Compaction will be with mechanical plate compactors to achieve 95% of maximum standard Proctor density (ASTM D 698).
 7. All SRW units shall be installed at the proper elevation and orientation as shown on the final, P.E.-sealed wall plans and details or as directed by the Wall Design Engineer. The SRW units shall be installed in accordance with the manufacturer's recommendations.
 8. First course of SRW units shall be placed on the leveling pad. The units shall be leveled side-to-side, front-to-rear, and with adjacent units, and aligned to ensure intimate contact with the leveling pad. The first course is the most important to ensure accurate and acceptable results, and each unit in the first course shall be in full contact with base. No gaps shall be left between the front of adjacent units. Alignment may be done by means of a string line or offset from base line to the back of the units.
 9. Connection pins per the manufacturer's requirements and P.E.-engineered design shall be inserted through the pin holes of each upper-course unit into receiving slots in lower-course units. Pins shall be fully seated in the pin slot below. Units shall be pushed forward to remove any looseness in the unit-to-unit connection.
 10. Place and compact drainage fill behind and around the SRW units. Place compacted On-Site Processed Fill and geogrid reinforcement, as applicable, behind drainage fill with filter fabric separating the two fill materials. Clean excess debris from top of units. Prior to placement of next course, the level and alignment of the units shall be checked and corrected where needed. Install next course and repeat procedures to the extent of the wall height.
 11. Drainage materials, and backfill shall be placed in sequence with unit installation as described below.
 12. Drainage aggregate shall be installed to the line, grades and sections shown on the final P.E.-sealed retaining wall plans. Drainage aggregate shall be placed to the minimum thickness shown on the construction plans between and behind units (a minimum of 1 cubic foot for each exposed square foot of wall face unless otherwise noted on the final wall plans).
 13. Drainage collection pipes shall be installed to maintain gravity flow of water from wall backfill. The drainage collection pipe shall be installed at the locations shown on the final construction drawings. The drainage collection pipe shall discharge to the on-site drainage system.
 14. The backfill shall be placed as shown in the final wall plans in the maximum compacted lift thickness of 6 inches and shall be compacted to a minimum of 95% of standard Proctor density (ASTM D 698) at a moisture content within 2% of optimum.
 15. Only hand-operated compaction equipment shall be allowed within 3 feet of the back of the wall units. Compaction within the 3 feet behind the wall units shall be achieved by at least three passes of a lightweight mechanical tamper, plate, or roller.

16. At the end of each day's operation, the Contractor shall slope the last level of backfill away from the wall facing and reinforced backfill to direct water runoff away from the wall face.
17. At completion of wall construction, backfill shall be placed level with final top of wall elevation. If final grading, paving, landscaping and/or storm drainage installation adjacent to the wall is not placed immediately after wall completion, temporary grading and drainage shall be provided to ensure water runoff is not directed at the wall nor allowed to collect or pond behind the wall until final construction adjacent to the wall is completed.
18. SRW caps shall be properly aligned and glued to underlying units with the approved, flexible, high-strength concrete adhesive. Rigid adhesive or mortar are not acceptable.
19. Caps shall overhang the top course of units by 3/4 inch to 1 inch. Slight variation in overhang is allowed to correct alignment at the top of the wall.
20. Apply approved masonry stain in accordance with the manufacturer's application instructions to a 10 square foot area as a mockup for Landscape Architect approval prior to completing the stain application. After approval of the stain mockup, complete the stain application at all exposed wall surfaces. Stain shall be applied by brush in a random pattern to individual molded stone subsets within the natural stone pattern of each block that along with the color admixture will resemble the natural appearance of the basis of design New England LedgeStone by Redi-Rock.
21. Apply the approved Sacrificial Anti-Graffiti Coating to exposed wall faces in accordance with the manufacturer's application instructions.

2.07 PRECAST CONCRETE WHEEL STOPS

- A. Submittals: Manufacturer's data including instructions, recommendations, and restrictions. Submit for each material and product.
- B. Precast concrete wheel stop: 3,500 psi rated concrete with 2 integral rebar pieces. Each wheel stop shall come with 3 pins for installation on asphalt pavement. Length: 6', Width: 6", Height: 5", Weight: 200 lbs each.
- C. Install per manufacturer's recommendations.

2.08 BOTTLE FILLING STATION

- I. Furnish and Install bottle filling station based on product Endura II Model 4420BF as manufactured by Halsey Taylor, Inc., Oak Brook, IL 60523. Phone: 630-574-3500, www.halseytaylor.com, or one of the following approved equals:
 1. LK4420BF as manufactured by Elkay, Inc. (<https://www.elkay.com/>) 800-476-4106
 2. Approved equal.
- J. Product specifications:
 1. Stainless steel, laminar flow pedestal bottle filling station
 2. ADA compliant
- K. Color shall be selected by Landscape Architect from palette of standard colors.

2.09 FABRICATED METAL RAILINGS AT LANDSCAPE STAIRS AND RAMPS

- A. Submittals: Manufacturer's data including instructions, recommendations, and restrictions. Submit for each material and product. Provide shop drawings engineered, prepared, sealed, and signed by the Contractor's engineer.
- B. Steel tubing for handrails, shall be round seamless steel pipe in accordance with ASTM A53/A53M-99B. Sizes and layout shall be as shown on the drawings. Factory applied powder

coat color:

- C. Custom RAL colors to be selected and approved by Landscape Architect. Colors to match colors select from Item 2.07 (prior paragraph).
 - Steel Railings: Factory applied powder coat colors: Custom RAL colors to be selected and approval by Landscape Architect. Color matched to Item 2.07
- D. Welding and Finishing: Refer to Item 2.07 for welding, galvanization and Factory-Applied Architectural Finish Powder Coat Finish Over Galvanized Steel process.
- E. Fabrication; As shown or, if not shown:
 - 1. Match design intent indicated
 - 2. Meet all Codes including barrier free regulations and requirements.
 - 3. Provide welded assembly.
 - 4. Return rail ends to walls or as indicated on drawings.
 - 5. Cap all visible ends and hollow members with welded caps.
 - 6. Fully shop fabricate work to the maximum extent possible.
 - 7. Shop prefit field seams and joints.
- F. Touch-up and Repair: For damaged coated surfaces, clean welds, bolted connections and abraded areas:
 - 1. At galvanized surfaces, apply organic zinc repair paint complying with requirements of ASTM A780. Galvanizing repair paint shall have 65 percent zinc by weight. Thickness of applied galvanizing repair paint shall be not less than coating thickness required by ASTM A123 or A153 as applicable. Touch-up of galvanized surfaces with aerosol spray, silver paint, bright paint, or aluminum paints is not acceptable.
- G. Warranty: The galvanizer shall furnish a warranty stating that the galvanizing topcoated in accordance with the specification shall remain free from more than 10% (percent) rust for a period of twenty (20) years.
- H. Handling: Galvanizer shall handle, pack, and ship in such a manner as to minimize damage to the finish. Upon arrival at job site it shall be the Contractor's responsibility to take equal precautions. Since some surface damage is inevitable, suitable touch-up material shall be readily available from the galvanizer for the Contractor's use.
- I. Shop Drawings: The contractor is required to provide detailed shop drawings for all metal fabrications specified herein.
 - 1. Stair and Ramp Handrails: The Contractor shall submit detailed final drawings plans, sections and elevations for approval prior to ordering materials.
 - 2. Contractor shall submit a full color palette selection of CUSTOM color choices for approval by landscape architect for all factory applied color galvanized materials.

2.10 HOT DIPPED GALVANIZED STEEL VEHICULAR BARRIER GATE

- A. Barrier gates and hinge posts shall be furnished, fabricated and hot-dipped galvanized under Section 055000 METAL FABRICATIONS. Install hot-dipped galvanized fabricated steel barrier gates as indicated on the drawings.
- B. Acceptable Manufacturers:
 - 1. Newgate Limited (Barriers Heavy Duty Manual Swing Arm), Newark, UK, 0808-156-1561

2. Hoover Fence Co. (V-series), Newton Falls, Ohio, 800-355-2335
3. Or approved equal.

C. Submittal:

1. Approved manufacturer's shop drawings shall become the basis for factory-finished surfaces and must therefore be submitted prior to installation.
2. The Contractor shall submit detailed shop drawings for footings for approval prior to installation. Drawings shall be prepared and sealed by a professional structural engineer (P.E.) experienced in design of similar structures and licensed in Massachusetts.

D. Materials:

1. Barrier gate and posts shall be manufactured from tubing, channels and rods, meeting the requirements of ASTM A 500-93 with an in line hot dipped Galvanized exterior zinc coating. The tubing finish will have an in-line hot dipped Galvanized Zinc coating, with a clear organic exterior coating and gray interior rust preventing coating. This material will have a minimum yield of 46,000 psi.
2. The manufacturer will supply gate hardware of sufficient size and capacity to support the specified gate.
3. Finish shall be an eight-stage pre-treatment and a four-stage corrosion resistant powder coating process. The finish shall conform to local environmental air quality standards. The landscape architect shall select the color from the fabricators list of standard colors, 6 minimum offerings, shall include Black and Deep Green.

E. Fabrication:

1. New prime material/galvanized steel, conforming to specified ASTM standards, shall be used in the manufacture of gates and posts.
2. Gates and posts shall be of welded construction by the gas metal arc method. The layout and welding shall be carried out by experienced craftsmen making sure all welds are neat, clean and of sizes matching those indicated on the drawing. Any and all flush welds shall be ground smooth.
3. After fabrication all posts, panels and gates shall be pre-treated to insure optimum coating adherence to the metal.

F. Installation:

1. Posts shall be set according to the spaces shown on the shop drawings. All posts shall be set plumb and level. Footing sizes shall be as indicated on the shop drawings as well as posts caps.

- G. Gates, where indicated on the Drawings, shall be installed according to the style and sizes indicated on the shop drawings and shall be installed plumb and level. Any required gate stops will be installed by the Contractor. To assure alignment of any padlock provisions or strikes, gate attachment will be done in the field. When installation is complete the Contractor will be responsible for lubricating the hinges, rollers and other gate hardware

2.11 ELECTRONIC BARRIER ARM VEHICULAR GATE

- A. Electronic barrier arm gates shall be furnished and installed under this section. Footing shall be furnished and installed under Section EXTERIOR CONCRETE – 321313. Security access

control coordination shall be referenced under the SECURITY sections. Install barrier gates as indicated on the drawings.

B. Acceptable Manufacturers:

1. LiftMaster, Model# MAT Mega Arm Tower High Performance Commercial DC Barrier Gate.
www.liftmaster.com
2. Or approved equal.

C. Submittal:

1. Approved manufacturer's shop drawings.
2. Installation instructions.
3. Access coordination instructions.

D. Materials:

1. Barrier gate shall be a metal enclosed cabinet.
2. Access control shall consist of a separate free-standing decorative bollard. Access shall be coordinate with the Owner and the Security Consultant. Access shall include multiple options, including but not limited to:
 - a. Keypad.
 - b. FOB or card reader.
 - c. Emergency siren.
 - d. Others.
3. Ground-loop vehicular detection. Gate shall include a ground-loop for vehicular detection. Exist gate shall have a free-release gate operation.

E. Installation:

2. Posts shall be set according to the spaces shown on the shop drawings. All posts shall be set plumb and level. Footing sizes shall be as indicated on the shop drawings as well as posts caps.
3. Gates, where indicated on the Drawings, shall be installed according to the style and sizes indicated on the shop drawings and shall be installed plumb and level. .

2.12 RECLAIMED GRANITE QUARRY TAILINGS

- A. Basis of Design is "Reclaimed Granite Quarry Tailings" by Stone Curators
www.stonecurators.com Please contact Jared Jackson for pricing –
jared@stonecurators.com , +1 (617) 283-4145
- B. See precedent image for the Reclaimed Granite Quarry Tailing. The granite blocks shall be stacked on top of each other to create some seating.



- C. The quantity specified for this project is in terms of weight/size
 - 1. The dimensions shall vary from smallest size being smallest at 1.0'x1.5'x2' (approx. 0.75 ton) to largest being 2.5 H 'x3.5L'x2W (2 tons)
 - 2. Qty shall be 0.75 ton (5)
 - 3. Qty shall be 1 ton (10)
 - 4. Qty shall be 2 tons (5)
 - 5. Total installed cost not to exceed \$30K
- D. The specifications for the granite is as follows
 - a. A reclaimed North American granite natural stone.
 - b. This stone can have a smooth to rough texture.
 - c. Granite chosen will be split-face with flat plane finishes.
 - d. The dominant color is gray; with beige, purple and white secondaries. Exhibits "movement" and the color mix creates a cool feeling. Regular, blotched, swirled and cloudy color pattern
- E. Landscape Architect shall select the exact samples from onsite during submittal process and work with the Contractor in exact layout of these on site.

2.13 ONSITE SALVAGED LANDSCAPE BOULDERS (QTY 30)

- A. Boulders selected for placement shall be salvaged existing boulders from on-site set aside.
 - a. Boulders selected for "Landscape Boulders or Seating Boulders" shall be derived from on-site
 - b. Minimum width dimensions ranging from 18 to 24 inches in height/width - **(Qty 18)**
 - c. Minimum width dimensions ranging from "3 to 4 feet" in height/width - **(Qty 12).**
 - d. Boulders shall be reviewed and selected from pile of salvaged boulders per above dimensions set aside, and approved by the landscape architect.
- B. Place selected boulders at the direction of the Architect, and generally as shown on the Contract Documents. Placement shall include adjustment of exposed face or orientation. The Contractor shall work with the Architect until approved orientation is achieved.
- C. Excavate to the lines and grades shown on the Contract Documents, and embed approximately 1/4 minimum of boulder below finish grade.

2.15 CLEANING, REPAIR AND PROTECTION

- A. Repair minor damages to eliminate all evidence of repair. Remove and replace work that cannot be satisfactorily repaired. All site improvements damaged by the contractor will be restored to their original state at their own cost.
- B. Provide temporary protection to ensure that the work will be without dirt, stains, damage or deterioration at time of final acceptance. Clean up stains and spills as they occur. Remove protections and clean as necessary immediately before final acceptance.
- C. Upon completion of the work and before acceptance, the Contractor shall remove and dispose of in an approved manner all surplus materials, rubbish, etc. which the Contractor may have accumulated during the course of the work and shall leave the site in a clean and orderly condition. The Contractor shall not abandon any material at or near the site regardless of whether or not it has any value.

END OF SECTION

SECTION 32 31 00
FENCING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 apply to the work of this Section.

1.02 DESCRIPTION OF WORK

- A. The work of this Section includes, but is not limited to the following:
1. Grading and Compaction of Sub-base
 2. Concrete Footings for Fencing
 3. Black Vinyl Coated Chain Link Fence and Gates
 4. Nylon privacy mesh windscreen with (and without) printed digital graphics
 5. Chain Link Backstops at Softball and Baseball
 6. Horizontal Wood Slat Screen Fence
 7. Cleaning, Repair and Protection.
- B. Sustainable Building Requirements:
1. The Contractor is to implement practices and procedures to meet the project's sustainable performance goals, which include achieving LEED v4 Silver certification based on USGBC's "LEED Version 4 for Building Design and Construction: Schools" (LEED v4 BD+C: Schools).
 2. The work of this Section includes responding to Architect or Contractor requests for additional information or product data and may be required following initial Green Building Certification Institute (GBCI) review of LEED Application.
 3. Product substitution requests are subject to additional LEED submittal requirements including, but not limited to, Environmental Product Declarations (EPD), Health Product Declarations (HPD), and General Emissions Testing.

1.03 RELATED WORK

- A. Carefully examine all of the Contract Documents for requirements that affect the work of this Section. Other specification sections that directly relate to the work of this Section include, but are not limited to, the following:
1. Section 116833 – Athletic Field Equipment
 2. Section 133411 - Pressbox
 3. Section 312000 - Earth Moving
 4. Section 321200 - Asphalt Paving
 5. Section 323000 – Site Improvements
 6. Section 321313 – Concrete Pavements
 7. Section 321823.13 –Baseball and Softball Field Surfacing

1.04 SUBMITTALS

- A. Refer to individual site improvements for additional submittal requirements.

- B. Provide manufacturer's product material information and system performance data along with material and system samples for each item specified in this Section for the Landscape Architect's review and approval prior to ordering materials.
- C. The General Contractor shall verify by field inspection that all items within this section conform to the specified requirements and approved submittals prior to installation.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials and products adequately protected against damage. Handle in strict compliance with manufacturer's instructions and recommendations and store off the ground. Protect from all possible damage including, but not limited to, chipping, staining, cracking and other damage. Cracked, chipped, or stained units will be rejected and shall not be utilized in this work. Sequence deliveries to avoid delays, but minimize on-site storage.

1.06 COORDINATION

- A. The work of this Section shall be coordinated with that of other trades affecting, or affected by, this work as necessary to assure the steady progress of the work of this Contract.
- B. Substrates: Proceed with work only when substrate construction and penetrating work is complete

1.07 REFERENCE STANDARDS

- A. Chain Link Fence Manufacturers Institute (CLFMI).
- B. American Society of Testing and Materials (ASTM).
- C. ASTM F1184 Specification for Industrial and Commercial Horizontal Slide Gates

1.08 GUARANTEE

- A. In addition to the specific guarantee requirements of the GENERAL CONDITIONS and SUPPLEMENTARY GENERAL CONDITIONS, the Contractor shall provide the manufacturers' standard written warranty for each product within this specification. All of these guarantees shall be in addition to, and not in lieu of, other liabilities that the Contractor may have by law or other provisions of the Contract Documents.

PART 2 - PRODUCTS & EXECUTION (Combined)

2.01 GRADING AND COMPACTION OF SUB-BASE

- A. Do all necessary grading in addition to that specified under Section 312000 – Earth Moving to bring subgrade or foundation after final compaction to required grades and sections to obtain a foundation of uniform bearing surface. In absence of specific requirements, compact foundation by such means as will provide firm base and insurance against settlement of superimposed work.
- B. Sub-base preparation, including material, shall be of properly approved quality as specified under Section 312000 - EARTH MOVING. Start of work under this Section shall constitute acceptance of the foundation conditions to which this work is to be applied. Any defects in work resulting from such conditions shall be corrected under this Section, at no additional cost to the Owner.

2.02 CONCRETE FOOTINGS FOR FENCING ITEMS

- A. Construct concrete footings where shown on the Drawings.
- B. Concrete for footings shall be 5,000 lb. concrete as specified in Section 03 30 00 –CAST-IN-PLACE CONCRETE.
- C. Place concrete on moist subgrade or against prepared footings in continuous operation between transverse joints or individual sections. Vibrate all concrete. Do not place concrete in freezing temperatures or on frozen base.

2.03 BLACK VINYL COATED CHAIN LINK FENCE AND GATES

A. Submittals:

1. Shop Drawings: Supply shop drawings at an approved scale for location, installation and erection of all components of the chain link fence and gates.
2. Product information: Provide manufacturer's product data showing installation and limitations in use. Supply Certificates of Compliance for all materials required for fabrication and installation.
3. Material Selection and Samples: Submit samples showing the material size, gauge and finish for all components required for construction, including but not limited to:
 - a) A 12"x12" sample of fence fabric.
 - b) A 12" section of each type of fence pipe required.
 - c) Provide 1 of each type of fitting required.
 - d) Provide a 6" sample of fabric tie material.
 - e) Provide 1 gate latch and 1 gate hinge (to be returned to the fence contractor upon completion of the installation).

B. Scope:

1. This specification covers colored chain link fence and gates, including chain link fabric, framework, and fittings. Fence heights / gate heights and widths shall be shown on the drawings.
- C. PVC Coating: Fence fabric and framework shall be thermally-fused vinyl coating over galvanized steel. "A Bonded or extruded and glued" fabric will not be accepted.
- D. Color: All fence material including fabric, framework, fittings, accessories, and hardware shall be black.
- E. Fabric: Fabric for all fences shall be a 2" diamond mesh unless otherwise noted. Fabric shall be #6 gauge core wire unless otherwise noted (0.192" nominal wire diameter) with a minimum breaking strength of 2170 pounds, thermally fused in accordance with ASTM F668-2b. The weight of the zinc coating on the steel wire shall be 0.3 oz. per square foot minimum. Chain link fabric shall be color matched with framework materials. Fabric shall be knuckled at both selvages.
- F. Framework: Shall consist of terminal posts, line posts, top rail, bottom rail, mid rail, truss rods at end and corner posts and gate frames.
- G. Posts and rails shall be steel pipe, Type 1: ASTM F 1083, standard weight, schedule 40, minimum yield strength of 25,000 psi, sizes as indicated below. Before color is applied, all materials shall be given a minimum 1.8 ounce per s.f. coating of zinc. PVC-coated finish shall be applied in accordance with ASTM F 1234, apply supplemental color coating of 12 mils (0.254-0.356 mm) of thermally fused PVC.

1. Sizes of Framework:

a) Fences less than 5' Height

Post or Rail	Outside Diameter	Pounds/Foot
End Corner & Pull Post	2.375"	3.65

Line Post	1.900"	2.72
Top and Bottom Rail	1.660"	2.27

2. Fences greater than 5' Height but less than 8' Height

- 1) Provide mid rail braces* between all end/corner posts and adjacent line posts at all fences 5' – 8' in height.

Post or Rail	Outside Diameter	Pounds/Foot
End Corner & Pull Post	2.875"	3.65
Line Post	2.375"	2.72
Top and Bottom Rail	1.660"	2.27
Mid Rail Braces*	1.660"	2.27

3. Fences equal to or greater than 8' Height:

- 1) Provide continuous mid rails* for all fences 8'-12' in height.

Post or Rail	Outside Diameter	Pounds/Foot
End Corner & Pull Post	4.0"	9.10
Line Post	2.875"	5.79
Top and Bottom Rail	1.660"	2.27
Mid Rail Braces*	1.660"	2.27

* Mid rails and mid rail braces at fences in front of players benches at baseball and softball dugouts shall be set at 3-feet above grade so as not to obstruct line of sight when seated on players benches.

- H. Top rail couplings 6-inch minimum in length shall be spaced at maximum 20-foot centers and 9-gauge minimum fabric tie wires shall be spaced at 18-inch maximum centers.
- I. Swing Gates: Gate openings shall be as indicated on the drawings. Gate height shall conform to the height of the fence unless otherwise indicated. Gate frames shall be fabricated with welded corners and braces. Frames shall be filled with chain link fabric of the same gauge and size as the fence. Gate post hinges shall be heavy-duty offset type furnished of adequate size and strength for the gate size specified and to allow a minimum 180-degree swing. Braces and trusses shall be furnished as specified as indicated below. Gate shall include a heavy duty galvanized and vinyl coated positive latching device that will accommodate a padlock and secure the gate in a closed position. Gate post sizes shall be as described below:

1. Swing gate post sizes: (per ASTM F900)

Gate height up to and including 6 ft. (1.2m)	
Gate leaf width	Post Outside Diameter
up to 4 ft.	2.375 in
over 4 ft. to 10 ft.	2.875 in

Gate height over 6 ft. to 12 ft. (1.2 to 2.4m)	
Gate leaf width	Post Outside Diameter
up to 6 ft.	4.000 in
over 6 ft. to 12 ft.	4.000 in
over 12 ft. to 18 ft.	6.625 in

2. Braces and truss rods at gates

- Include midrail brace in welded gate frame if gate is 5' height or greater.
- Include truss rods for all gate leaves that are 7' width or wider.

J. Accessories:

- Chain link fence accessories: ASTM F 626, Provide items required to complete fence system. Galvanize each ferrous metal item in accordance with ASTM A 153 and finish to match framing (Black Vinyl Coating).
- Post Caps: Formed steel, weather tight dome-shape closure cap. Provide one cap for each post. Caps shall be affixed to the post securely so as to prevent removal.
- Stretcher Bars: One-piece lengths equal to 2-inches less than full height of fabric with a minimum cross section of 3/16 inch x 3/4-inch. Provide stretcher bars where chain link fabric meets terminal posts.
- Tie Wire: 9-gauge vinyl coated galvanized steel wire for attachment of fabric to line posts.

K. General: Certain components not adaptable to the here in specified coating process may be color coated by other means. All fittings shall be pressed steel or malleable iron. Tie wires shall be minimum 9-gauge PVC coated steel or 6-gauge aluminum. Line and terminal posts to be of sufficient length to be set to the full depth of concrete footing indicated on the Drawings. Maximum spacing of line posts shall be 10-feet.

- Each fence panel shall be constructed such that it will pass the following test. Deflection of the fence fabric shall be no greater than 2 inches when a force of 30 pounds is applied in the center of a framed panel, perpendicular to the plane of the

fence fabric. Fabric shall return to original position true to the plane of the fence when force is released.

2.04 WINDSCREEN WITH DIGITAL GRAPHICS

- A. Furnish and install model "VCP6DG – 6' HT Windscreen with Digitally Printed Graphics and Windscreen Material and Accessories, by Sportsfield Specialties, Delhi, NY, (888) 975-3343 or approved equal.
1. Vinyl Coated Polyester Mesh (VCP/VCM) 9 x 12
 2. Base Fabric: 9 x 12 1000 Denier Polyester
 3. Weight (Test Method 5041): Eight Ounces (8 oz.) Per Square Yard, Plus or Minus One Ounce (1 oz.)
 4. Eighty Percent (80%) Closed Mesh, Twenty Percent (20%) Open
 5. Tensile Strength (Test Method 5100-Warp x Fill): 210 x 220lbs.
 6. Adhesion (Test Method 5970-Warp x Fill): 8 x 8 lbs./2"
 7. Tear Strength (Test Method 5134-Warp x Fill): 90 x 90 lbs.
 8. Double Stitched Perimeter Seam Using 6 lb. Bonded Polyester Black Thread, Heat Sealable
 9. #2 Brass Grommets Inserted in Perimeter Hem Every Twelve Inches (12") on Center and Corners for Attachment Purposes
 10. Weather, Ultraviolet (UV), Rot, Mildew and Flame Resistant
 11. Color: To be approved by architect from standard colors
 12. Custom High Resolution Digitally Printed Graphics.
 - i. Vector Artwork will be provided by the Landscape Architect
 - ii. Vendor shall provide rendering with Graphics for final approval
 13. Three (3) Year Limited Product Warranty
- B. Windscreen shall be securely zip-tied to chain link fence using high-quality, heavy-duty color matching ties.

2.05 BASEBALL AND SOFTBALL BACKSTOP

- A. Submit Shop drawings: Layout of fences and gates with dimensions, details, and finishes of components, accessories, and post foundations.
- B. Product data: Manufacturer's catalog cuts indicating material compliance and specified options.
- C. Chain link fabric:
1. Thermally fused vinyl coating, 6 mil to 10 mil thickness, thermally fused to zinc-coated steel core wire: Per ASTM F 668 Class 2b. Minimum core wire tensile strength of 75,000 psi
 2. Roof fabric: 2" diamond mesh of 9-gauge core wire with a diameter of 0.148" and a break load of 1290 lbs. Color midnight black ASTM F 934.
 3. Side Fabric: Woven to height of 16 ft., or as indicated on drawings, with 2" diamond mesh of 6-gauge core wire with a diameter of 0.192" and a break load of 2170 lbs. Color midnight black ASTM F 934

4. Selvage of fabric knuckled at top and knuckled at bottom.

D. Steel Framing

1. Thermally fused vinyl coating
2. Steel pipe - Type I: ASTM F 1083, standard weight schedule 40; minimum yield strength of 30,000 psi ; sizes as indicated. Hot-dipped galvanized.
3. End and Corner Post: 4" OD, 9.11 lbs per/ft. Line (intermediate) Post: 4" od, 9.11 lbs per/ft
4. Horizontal rails and roof members 1.9" od, 2.72 lbs per/ft

E. Accessories

1. Chain link fence accessories: ASTM F 626, Provide items required to complete fence system. Galvanize each ferrous metal item in accordance with ASTM A 153 and finished to match framing.
2. Post caps: Formed steel or cast malleable iron weather tight closure cap for tubular posts. Provide one cap for each post, except where barbed wire supporting arms are indicated. "C" shaped line post without top rail or barbed wire supporting arms do not require post caps. (Where top rail is used, provide tops to permit passage of top rail.)
3. Top rail and rail ends: Pressed steel per ASTM F626, for connection of rail and brace to posts.
4. Top rail sleeves: 7" (178 mm) expansion sleeve with minimum .137" wire diameter and 1.80" length spring, allowing for expansion and contraction of top rail.
5. Tie Wire: 9gauge vinyl coated galvanized steel wire for attachment of fabric to line posts. Double wrap 13 gauge for rails and braces. Hog ring ties of 12-1/2 gauge for attachment of fabric to tension wire.
6. Brace and tension (stretcher bar) bands: Pressed steel, minimum 300-degree profile curvature for secure fence post attachment. At square post provide tension bar clips.
7. Tension (stretcher) bars: One-piece lengths equal to 2" (50 mm) less than full height of fabric with a minimum cross-section of 3/16" x 3/4" (4.76 mm x 19 mm). Provide tension (stretcher) bars where chain link fabric meets terminal posts.
8. Tension wire: Zinc coated steel wire: Per ASTM F 1664 Class 2 b, 6 gauge, [0.192" (4.88 mm)] diameter core wire with tensile strength of 75,000 psi (517 MPa).
9. Truss rods & tightener: Steel rods with minimum diameter of 5/16" (7.9 mm). Capable of withstanding a tension of minimum 2,000 lbs.
10. Nuts and bolts are galvanized.

2.06 HORIZONTAL WOOD SLAT SCREEN FENCE

- A. Furnish and install a wood screen fence and gates as shown on the Drawings. All wood materials shall be Northern White Cedar, rough sawn to the dimensions and profiles shown on the Drawings. Provide complete material and layout shop drawings to scale for review and

approval by the Architect prior to ordering material. Posts shall be plumb in all directions and then securely set in concrete footings.

- B. Stain fence on all exposed surfaces with Defy UV Resistant, Clear Wood Finish, Olympic 56400A/01 Clear Waterproofing Sealant, or Architect approved equal.
- C. Fence hardware: Standard galvanized The fence shall be fabricated with galvanized steel C posts, brackets and eastern white cedar horizontal rails.

PART 3 - EXECUTION

3.01 CHAIN LINK FENCE INSTALLATION

- A. Erect chain link fencing only after final grading is complete. Install fence fabric and bolt heads on one side of fence and bolt nuts on the other side.
 - 1. Level: Install all fence work, including fences over irregular terrain, with posts plumb and top of fence fabric and rails level, except as indicated otherwise and except at regular slopes and hills, install top of fence fabric and rails to follow slope.
 - 2. Posts Set in Ground: Accurately space posts at approximately (8) feet on center, unless otherwise indicated or required, and excavate neat, circular holes at least four times the diameter of the post and at least 6 inches below post. For all other posts set posts at least (3) feet below finish grade or as shown on the details and center align posts in hole with 6 inches of concrete beneath posts. Fill holes with concrete and vibrate and consolidate around posts. Maintain true vertical and top alignment and alignment along the fence line. Extend concrete footings to (2) inches below finish grades and slope to shed water away from posts. Align posts and fence fabric to permit paving to continue around fence posts so that concrete fence post footing does not show.
 - 3. Rails: Provide top, mid-rail as applicable, and bottom rails continuously with expansion couplings as recommended by fence manufacturer. Install intermediate rails, where used, flush with face fabric using offset fittings if necessary. Provide intermediate rails for all fences over (6) feet high.
 - 4. Fabric: Thread tension bars through fabric and clamp to fabric at 4 inches on center. Band stretcher bars to end posts at (12) inches on center. Stretch fabric tightly and securely anchor fabric to framing and tension wires leaving about (1) inch clearance above grade. Anchor and tie so that fabric remains in tension after pulling force is released. Form joints of splices in fabric only at posts. Tie fabric to line posts at (12) inches on center, to rails and braces at (24) inches on center, and to tension wires at (24) inches on center with U-shaped tie wires double turned with ends bent into fence for safety.
 - 5. PVC Coated Work: Generally, comply with requirements for galvanized work. Take extreme care to prevent removal of or damage to PVC coatings. Touch-up all cut and abraded surfaces with PVC tough-up paint to prevent corrosion and to make tough-up invisible.

3.02 CLEANING, REPAIR AND PROTECTION

- A. Repair minor damage to eliminate all evidence of repair. Remove and replace work that cannot be satisfactorily repaired.
- B. Provide temporary protection to ensure that the work will be without dirt, stains, damage or deterioration at time of final acceptance. Clean up stains and spills as they occur. Remove protections and clean as necessary immediately before final acceptance.

- C. Upon completion of the work and before acceptance, the Contractor shall remove and dispose of in an approved manner all surplus materials, rubbish, etc. which the Contractor may have accumulated during the course of the work and shall leave the site in a clean and orderly condition. The Contractor shall not abandon any material at or near the site regardless of whether or not it has any value.

END OF SECTION

SECTION 32 33 00
SITE FURNISHINGS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. This section is only a portion of the Contract Documents. All of the Contract Documents, including Conditions of the Contract and Division 1 General Requirements, apply to this section.

1.02 DESCRIPTION OF WORK

- A. All site furnishings in this section shall be installed by the Contractor as indicated in the Drawings.
- B. The work of this section includes, but is not limited, to the following:
- I. Straight Gabion Bench with Wood Topper
 - II. Curved Gabion Bench with Wood Topper
 - III. Straight Recycled Plastic Bench
 - IV. Café Wood Stools
 - V. Café Dining Table
 - VI. Café Metal Chair
 - VII. Café Counter Height Table
 - VIII. Playground Metal Picnic Table/Seats
 - IX. Trash and Recycling Receptacles
 - X. Bicycle Racks
- C. The following items shown on the Drawings and/or noted herein shall be furnished and installed under their Sections of the specifications:
- I. Concrete for concrete footings under 03 30 00 Cast in Place Concrete
 - II. Section 31 00 00 Earthwork for excavation for installing concrete footings.
 - III. Concrete paving under 32 13 13 Exterior Concrete.
- D. Sustainable Building Requirements:
- I. The Contractor is to implement practices and procedures to meet the project's sustainable performance goals, which include achieving LEED v4 **Silver** certification based on USGBC's "LEED Version 4 for Building Design and Construction: Schools" (LEED v4 BD+C: Schools).

- II. The work of this Section includes responding to Architect or Contractor requests for additional information or product data and may be required following initial Green Building Certification Institute (GBCI) review of LEED Application.
- III. Product substitution requests are subject to additional LEED submittal requirements including, but not limited to, Environmental Product Declarations (EPD), Health Product Declarations (HPD), and General Emissions Testing.

1.03 RELATED WORK

- A. Carefully examine all the Contract Documents for requirements that affect the work of this Section. Other specification sections that directly relate to the work of this Section include, but are not limited to the following:
 - I. Section 31 00 00 – Earthwork
 - II. Section 31 10 00 – Site Clearing and Preparation
 - III. Section 32 12 16 – Asphalt Paving
 - IV. Section 32 13 13 – Exterior Concrete
 - V. Section 32 16 00 – Curbing
 - VI. Section 32 30 00 – Site Improvements

1.04 SUBMITTALS

- A. Shop Drawings: Refer to individual site furnishings for submittal requirements.
- B. Provide manufacturer's product material information and system performance data along with material and system samples for each item specified in this Section for the Architect's review and approval prior to ordering materials.
- C. The General Contractor shall verify by field inspection that all items within this section conform to the specified requirements and approved submittals prior to installation.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials and products and provide adequate protection against damage. Handle in strict compliance with manufacturer instructions and recommendations and store off the ground. Protect from all possible damage including, but not limited to chipping, staining, cracking, and other damage.
- B. Deliver materials in manufacturer's original unopened and undamaged packages with labels legible and intact.
- C. Store materials in unopened packages in a manner to prevent damage from the environment and construction operations.
- D. Handle in accordance with manufacturer's instructions.

1.06 COORDINATION

- A. The work of this Section shall be coordinated with that of other trades affecting, or affected by, this work as necessary to assure the steady progress of the work of this Contract.
- B. Substrates: Proceed with work only when substrate construction and penetrating work is complete.

1.07 GUARANTEE

- A. In addition to the specific guarantee requirements of the GENERAL CONDITIONS and SUPPLEMENTARY GENERAL CONDITIONS, the Contractor shall provide the manufacturers' standard written warranty for each product within this specification. All of these guarantees shall be in addition to, and not in lieu of, other liabilities that the Contractor may have by law or other provisions of the Contract Documents.
- B. Product Liability Insurance: The manufacturer of the playground equipment shall maintain, and have in effect at the time of the completed installation, an insurance policy covering completed operations (Product Liability) with a minimum limit of \$1,000,000.00 (One Million Dollars). A certificate of insurance shall be available to the project owner on request.
- C. Guarantees: The manufacturer shall furnish a written guarantee, covering the replacement of any damaged Structures or components, at no extra charge for the period of 15 (Fifteen) years. This guarantee does not cover Structures damaged by improper use or vandalism. Labor is not covered in this guarantee.

1.08 WARRANTIES

- A. 10-Year Limited Warranty for all stainless-steel fasteners, aluminum posts, clamps, beams and caps, against structural failure due to corrosion/natural deterioration or manufacturing defects. This warranty does not include any cosmetic issues or wear and tear from normal use.
- B. 15-Year Limited Warranty for all plastic and steel components, against structural failure due to corrosion/natural deterioration or manufacturing defects. This warranty does not include any cosmetic issues or wear and tear from normal use.
- C. The Contractor shall warrant that all structures and/or equipment installed will conform in kind and quality to the specifications set forth above and will be free of defect in workmanship and material.
- D. The Contractor shall offer a 10-year limited warranty for all aluminum and all posts, clamps, beams, and caps against structural failure due to corrosion, deterioration, or workmanship (cosmetic issues excluded).
- E. The Contractor shall offer a 10-year limited warranty for all plastic and steel components against structural failure due to corrosion, deterioration, or workmanship (cosmetic issues excluded).
- F. The Contractor shall offer a 1-year limited warranty for all moving parts, swing seats and swing hangers bumpers and other equipment not included above against failure due to corrosion, deterioration, or workmanship.
- G. An authorized representative of the play equipment manufacturer must inspect and approve the completed installation. The play equipment will not be accepted by the play equipment manufacturer or the Owner until they are satisfied with the installation. No additional compensation will be given for any necessary corrective work. Contractor shall submit written certification from Manufacturer's Representative that all play equipment has been installed in accordance with manufacturer's prescribed standards.

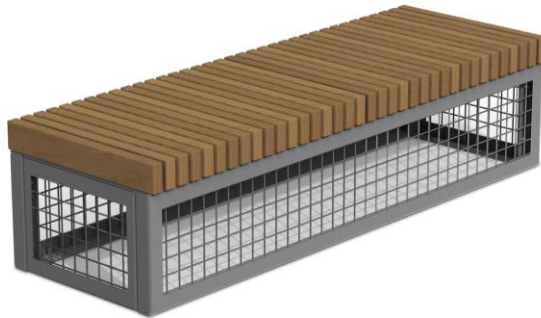
PART 2 - PRODUCTS AND EXECUTION (COMBINED)

2.01 SITE FURNISHINGS

- A. Basis of Design for all benches and stools only, shall be Anova Site Furnishings (www.anovafurnishings.com) or approved equal. All furnishings are surface mounted. All wood from Anova furnishings shall be Thermally Modified Ash. Please contact rep David Traphagen for pricing (david.t@anovafurnishings.com).
- B. Basis of Design for all other site furnishings other than benches shall be Landscape Forms (www.landscapelforms.com) or approved equal. All furnishings except stools/chairs are surface mounted. All wood from Landscape Forms shall be Thermally Modified Ash. Please contact rep. Nadene Worth for pricing (nadenew@landscapelforms.com).
- C. All the site furnishings shall preferably come from a single manufacturer for aesthetic/material/color/maintenance purposes. Alternative manufacturers provided below for each are acceptable provided they meet or exceed the requirements of the specifications as stated.

Acceptable Manufacturers:

- I. Custom by Site-Craft (www.site-craft.com)
 - II. Maglin Site Furniture (www.maglin.com)
- D. Straight Gabian Bench with Wood Topper – Basis of Design is Canyon Collection" by Anova Site Furnishings with the following specifications or approved equal
- 1) Model – CE18C18T Canyon Edge R18" Curved Bench w/Thermory
 - 2) Qty – 6
 - 3) Representative photo shown below:



- 4) Material:
 - a. The 6' gabion-style bench is composed of 1.5" x 3.5" Thermory seat planks
 - b. The bench cage is constructed from a frame that is 10-gauge, carbon steel and type 304 stainless steel mesh panels with a .1875" wire diameter.
 - c. The frame features 2" slots that accept 3/8" anchors for surface mounting to prevent movement.
 - d. The bench is designed to support 200 lbs. per linear foot.
 - e. Low-maintenance Thermory planks are made from thermally-modified North American White Ash - a sustainably-harvested and renewable temperate hardwood. It is an environmentally-friendly hardwood and a great alternative to commonly used tropical rainforest hardwoods because of its dimensional stability and Class 1 durability (25+ years). Thermory has a lower carbon footprint than tropical hardwoods.

- 5) Finish:
 - a. Fade resistant, powder coated steel and stainless steel components feature a state-of-the-art primer proven to prevent rusting.
 - b. Treated components exceed the industry standard by 34% in testing by independent sources.
 - c. Thermory is a lustrous chocolate brown color when new and will naturally age to uniform silver/gray over time. The color-changing process begins immediately and varies with the amount of UV-exposure
 - 6) Color: The color shall be standard color "Pine" for all the metal finish.
 - 7) Assembly The bench requires some assembly; stainless steel assembly hardware is included. The seating surface ships pre-assembled
 - 8) Install per manufacturer's instructions at locations indicated on the Drawings.
- E. Curved Gabian Bench with Wood Topper – Basis of Design is Canyon Collection" by Anova Site Furnishings with the following specifications or approved equal
- 1) Model – CE1872T Canyon Edge 6' Linear Bench w/Thermory
 - 2) Qty – 8
 - 3) Representative photo shown below:



- 4) Material:
 - f. The 5' gabion-style bench is composed of 1.5" x 3.5" Thermory seat planks
 - g. The bench cage is constructed from a frame that is 10-gauge, carbon steel and type 304 stainless steel mesh panels with a .1875" wire diameter.
 - h. The frame features 2" slots that accept 3/8" anchors for surface mounting to prevent movement.
 - i. The bench is designed to support 200 lbs. per linear foot.
 - j. Low-maintenance Thermory planks are made from thermally-modified North American White Ash - a sustainably-harvested and renewable temperate hardwood. It is an environmentally-friendly hardwood and a great alternative to commonly used tropical rainforest hardwoods because of its dimensional stability and Class 1 durability (25+ years). Thermory has a lower carbon footprint than tropical hardwoods.
- 5) Finish:
 - d. Fade resistant, powder coated steel and stainless steel components feature a state-of-the-art primer proven to prevent rusting.
 - e. Treated components exceed the industry standard by 34% in testing by independent sources.
 - f. Thermory is a lustrous chocolate brown color when new and will naturally age to uniform silver/gray over time. The color-changing process begins immediately and varies with the amount of UV-exposure
- 6) Color: The color shall be standard color "Pine" for all the metal finish.

- 7) Assembly The bench requires some assembly; stainless steel assembly hardware is included. The seating surface ships pre-assembled.
 - 8) Install per manufacturer's instructions at locations indicated on the Drawings
- F. Straight Recycled Plastic Bench - – Basis of Design is "Infinity Collection" by Anova Site Furnishings with the following specifications or approved equal

- 1) Model – PINF24L5R Infinity 2' x 5' Linear Recycled Plastic Bench
- 2) Qty – 3
- 3) Representative photo shown below:



- 4) Material:
 - a. The linear bench is composed of 1.50" x 3.50" actual recycled plastic planks and steel frame and supports.
 - b. The bench is 60" long and 24.00" wide. A configured bench supports 200 lbs. per linear foot.
 - c. The bench is designed to be surface mounted using pre-drilled 0.50" diameter holes in the supports to prevent movement. Mounting hardware is not included.
 - d. The planks are made of 95% recycled content by weight and are impervious to moisture and corrosion, do not require the application of sealants or preservatives, and will never need painting or staining throughout the products life.
- 5) Finish:
 - a. Fade-resistant, powder coated steel frame and supports feature a state-of-the-art primer proven to prevent rusting.
 - b. Treated components exceed the industry standard by 34% in testing by independent sources
- 6) Color: The color shall be standard color "Pine" for all the metal finish
- 7) Assembly: Each linear section ships partially assembled. Assembly includes stainless steel hardware
- 8) Install per manufacturer's instructions at locations indicated on the Drawings.

G. Café Wood Stools – Basis of Design is MIX2927T Mixx Thermory Stool by Anova Site Furnishings.

1. **Qty 28**
2. Dimension: 18"H x 15" Sq
3. Material:
 - a. The 15.32" square stool is composed of 0.75" x 3.5" (1" x 4" nominal dimensions) Thermory seat planks. The frame and supports are made of 14-gauge steel and are designed to support 200 lbs. per linear foot. The stool is designed to be portable for flexibility in placement.
 - b. Each foot features a stainless steel adjustable glide for leveling and to protect your floors.
4. Finish:
 - a. Fade-resistant, powder coated steel frame and supports feature a state-of-the-art primer proven to prevent rusting.
 - b. Treated components exceed the industry standard by 34% in testing by independent sources
5. Color: The color shall be standard color "Pine" for all the metal finish
6. Assembly: Each linear section ships partially assembled. Assembly includes stainless steel hardware.

H. Café Dining Table – Basis of Design is "Tables" (Catena base and Marneaux table top) by Landscape Forms with the following specifications

1. **Qty 13**
2. Marneaux Solid Surface Tabletops: 36" square tabletop with metal base, 29" height, with umbrella hole. 100% acrylic resin solid surface material, non-porous, man-made solid surface from a mixture of acrylic resin polymer, alumina trihydrate filler and other recycled fillers.
3. Surface materials shall be Solid Surface Marneaux in color "Pebble" or "Mist" (Final color selection shall be selected by Landscape Architect during submittals)
4. Table Supports: Catena base surface mounted – 3" outer diameter 0.120" wall steel tubing welded to 23" diameter cast iron base
5. Surface mount – bolted on anchor tabs, install per manufacturer's instructions in the locations indicated on the Drawings.

I. Café Metal Chairs - Basis of Design is "Chair 21" by Landscape Forms with the following specifications:

- 1) **Qty (24)**
- 2) Dimensions:
 - a. Backed. Depth: 25 ¼ inches Height: 32-3/4 inches
 - b. With Arms – 28-1/4" overall width
 - c. Stackable
- 3) Material
 - a. Seat Slats: 319 ASTM B26 or A413 ASTM B85 cast aluminum, attached to frame with Magn-coated ¼-20" x ½" flanged button head cap screws and washers.
 - b. Legs and Frame: 1-inch O.D. by 0.065-inch wall cold rolled steel tube, with A1008 CR or A1011 HRPO commercial steel tabs welded on for bolting to seat slats
 - c. Stem Bumper: Clear Vinyl
 - d. Glide: non-marring 6/6 nylon
- 4) Mounting: Shall be U-hook on one leg and manufacturer shall supply the material and instructions for the same

- 5) Finishes: metal powder coat color to be selected by Landscape Architect during submittal process. There shall be a mix of two colors
- J. Café Counter Height Table – Basis of Design is “Tables” (Catena base and Marneaux table top) by Landscape Forms with the following specifications
1. (Qty 3)Marneaux Solid Surface Tabletops: 36” square tabletop with metal base, **36” custom height**, no umbrella hole. 100% acrylic resin solid surface material, non-porous, man-made solid surface from a mixture of acrylic resin polymer, alumina trihydrate filler and other recycled fillers.
 2. Surface materials shall be Solid Surface Marneaux in color “Pebble” or “Mist” (Final color selection shall be selected by Landscape Architect during submittals)
 3. Table Supports: Catena base surface mounted – 3” outer diameter 0.120” wall steel tubing welded to 23” diameter cast iron base
 4. Surface mount – bolted on anchor tabs, install per manufacturer’s instructions in the locations indicated on the Drawings
- K. Playground Metal Picnic Table Seat – Basis of Design is Model “**Carousel Steelhead with wood insert**” with the following specifications
1. **Qty (1)**
 2. Dimensions: 5 Seat Backless ADA Dining Height (86”D x 33’H)
 3. The metal tabletops shall be formed of heavy gauge steel reinforced with channels beneath
 4. The supports for the table and seats shall be formed of 2” steel tubing
 5. The table shall be a solid powder coated metal with a rolled edge and wood insert. The wood shall be thermally modified Ash or another sustainable FSC certified hardwood
 6. All the seats shall have an open grid pattern.
 7. All tables shall have an umbrella hole opening.
 8. All tables shall be surface mounted
 9. The color for the table and the seats shall be selected by Landscape Architect during the submittal process
- L. Trash and Recycling Receptacles – Basis of Design is “Generation 50 Litter” with side open by Landscape Forms
1. Quantity (6)
 2. Materials: Side panel constructed of ¾”x2” solid stock boards with eased edges. Secure to frame with Magni-coated screws. Exterior – domestically sourced thermally modified ash. Interior - domestically sourced thermally modified ash. Front panel and inner frame shall be formed carbon steel sheet. Liner and base – rotationally molded linear low density polyethylene, color: black.
 3. Finish: color and finish of metal to be selected by Landscape Architect during submittal process. Wood shall be unfinished for exterior use.
 4. Surface mount with non-corrosive anchoring hardware per manufacturer’s instructions in the locations indicated on the Drawings.
- M. Bicycle Racks - Basis of Design is “Flow Bike Rack” by Landscape Forms
1. Quantity (3)

2. Materials: Stainless steel, type 304 ASTM A554. Outside diameter: 1.5", wall thickness: 0.102"-0.112"
3. Color/finish shall be electro polished stainless steel
4. Surface Mounted: surface mount tabs shall be ¼" thick 304 stainless steel, welded to frame
5. Install in accordance with manufacturer's instructions at locations indicated on the Drawings. Install level and anchor securely in place to concrete pad

2.02 CLEANING, REPAIR AND PROTECTION

- A. Repair minor damage to eliminate all evidence of repair. Remove and replace work that cannot be satisfactorily repaired.
- B. Provide temporary protection to ensure that the work will be without dirt, stains, damage or deterioration at time of final acceptance. Clean up stains and spills as they occur. Remove protections and clean as necessary immediately before final acceptance.
- C. Upon completion of the work and before acceptance, the Contractor shall remove and dispose of in an approved manner all surplus materials, rubbish, etc. which the Contractor may have accumulated during the course of the work and shall leave the site in a clean and orderly condition. The Contractor shall not abandon any material at or near the site regardless of whether or not it has any value.

END OF SECTION

SECTION 32 34 13
PEDESTRIAN BRIDGES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. This section is only a portion of the Contract Documents. All of the Contract Documents, including Conditions of the Contract and Division 1 General Requirements, apply to this section.

1.02 DESCRIPTION OF WORK

- A. The work of this section includes, but is not limited, to the following:
1. Prefabricated galvanized structural steel framed raised Boardwalk Ramp and Stairs
 2. Cleaning, Repair and Protection
- B. Sustainable Building Requirements:
1. The Contractor is to implement practices and procedures to meet the project's sustainable performance goals, which include achieving LEED v4 Silver certification based on USGBC's "LEED Version 4 for Building Design and Construction: Schools" (LEED v4 BD+C: Schools).
 2. The work of this Section includes responding to Architect or Contractor requests for additional information or product data and may be required following initial Green Building Certification Institute (GBCI) review of LEED Application.
 3. Product substitution requests are subject to additional LEED submittal requirements including, but not limited to, Environmental Product Declarations (EPD), Health Product Declarations (HPD), and General Emissions Testing.

1.03 RELATED WORK

- A. Carefully examine all the Contract Documents for requirements that affect the work of this Section. Other specification sections that directly relate to the work of this Section include, but are not limited to the following:
1. Section 012300 - Alternates
 2. Section 116833 – Athletic Field Equipment
 3. Section 311000 – Site Clearing and Preparation
 4. Section 312000 – Earthwork
 5. Section 321313 – Concrete Paving
 6. Section 321200 - Asphalt Paving
 7. Section 321823.13 –Softball Field Surfacing
 8. Section 323100 - Fencing
 9. Section 329100 – Loam and Planting Preparation
 10. Section 323300 – Site Furnishings
 11. Section 334000 - Storm Drainage Utilities

1.04 SUBMITTALS

- A. Shop Drawings:
 - 1. Provide scaled shop drawings for all components and connections of the steel frame and deck system.
- B. Provide manufacturer's material data sheets.
- C. Certification of steel origin (United states).
- D. Provide installation process and requirements including proposed vehicles and/or equipment.
- E. Provide structural calculations for key boardwalk elements.
- F. Business Data:
 - 1. Proof of business in good standing with all agencies including, reporting agencies, banks, and the state for which it operates.
 - 2. Proof of business operations greater than 7 years.
 - 3. Affidavit of employed American Welding Society certified welders.
 - 4. Three references for similar scale projects.
- G. Provide manufacturer's product material information and system performance data along with material and system samples for each item specified in this Section for the Architect's review and approval prior to ordering materials.
- H. The General Contractor shall verify by field inspection that all items within this section conform to the specified requirements and approved submittals prior to installation.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Deliver materials and products and provide adequate protection against damage. Handle in strict compliance with manufacturer instructions and recommendations and store off the ground. Protect from all possible damage including, but not limited to chipping, staining, cracking and other damage. Sequence deliveries to avoid delays but minimize on-site storage.

1.06 COORDINATION

- A. The work of this Section shall be coordinated with that of other trades affecting, or affected by, this work as necessary to assure the steady progress of the work of this Contract.
- B. Substrates: Proceed with work only when subgrade preparation work is complete.

1.07 GUARANTEE

- A. In addition to the specific guarantee requirements of the GENERAL CONDITIONS and SUPPLEMENTARY GENERAL CONDITIONS, the Contractor shall provide the manufacturers' standard written warranty for each product within this specification. All of these guarantees shall be in addition to, and not in lieu of, other liabilities that the Contractor may have by law or other provisions of the Contract Documents.
- B. Warranty.

1. Workmanship of the frames is warranted against defect for the life of the boardwalk. During this period, if the product is covered by the warranty and fails under normal use, manufacturer will repair or replace at original owners' discretion. The decking and other non-frame elements of the boardwalk are excluded. "Lifetime" is defined as the lifetime of the product in use.
2. Material warranty of all non-boardwalk frame material is that of the original manufacturer. Non-boardwalk material includes but is not limited to decks, handrail, curb rail, benches, or other fixtures.

PART 2 - PRODUCTS

2.01 CONCRETE FOOTINGS FOR RAISED BOARDWALK

- A. Construct concrete footings as indicated on the Drawings.
- B. Concrete for footings shall have 28-day compressive strength of 5,000 PSI as specified in Section 321313 Exterior Concrete.
- C. Place concrete on moist subgrade or against prepared footings in continuous operation between transverse joints or individual sections. Vibrate all concrete. Do not place concrete in freezing temperatures or on frozen base.

2.02 GRADING AND COMPACTION OF SUB-BASE

- A. Do all necessary grading in addition to that specified under Section 312000 - EARTHWORK to bring subgrade or foundation after final compaction to required grades and sections to obtain a foundation of uniform bearing surface. In absence of specific requirements, compact foundation by such means as shall provide firm base and insurance against settlement of superimposed work.
- B. Sub-base preparation, including material, shall be of properly approved quality as specified under Section 312000 - EARTHWORK. Start of work under this Section shall constitute acceptance of the foundation conditions to which this work is to be applied. Any defects in work resulting from such conditions shall be corrected under this Section 323413, Pedestrian Bridges, at no additional cost to the Owner.

2.03 RAISED BOARDWALK RAMP AND STAIRS

- A. Basis of design for Raised Boardwalk Ramp and Stairs is by Wickcraft Company, Inc. 2317 Daniels Street, Madison, WI 53718. (www.wickcraftboardwalks.com). Contact: Patrick Walters, email: patrick@wickcraft.com Tel: 608-496-1082.

- a. Additional Approved Manufacturers:

- i. Modular Trail Structures. PO Box 7383 Madison, WI 53707. (<https://www.modulartrailstructures.com/>). Contact Brian Kuehn, email: brian@modulartrailstructures.com tel: 608-609-9277

- ii. Custom Metal Fabrication.

- b. Qualified Equals. The use or substitution of a qualified equal boardwalk supplier, design, or material must be pre-approved prior to submitting bid and satisfy all pre-qualification criteria below:

- i. Contractor/Supplier shall show evidence that all structural welding must be performed by American Welding Society (AWS) certified welders.
- ii. Contractor/Supplier shall show evidence that no structural fabrication is performed by other sub-contractors or transferred to other entities not

approved under this contract.

- iii. Contractor/Supplier shall show evidence of at least five (5) years of experience or evidence of comprehensive experience in their construction discipline and (3) years management experience of their respective business or related managerial equivalent experience.
 - iv. Contractor/Supplier shall list the last five (5) construction projects completed including the names, addresses, and phone numbers of project contacts. Provide a brief description of each project and their respective contract amount.
 - v. Contractor/Supplier shall provide an inventory of trade specific equipment owned and show evidence of equipment and facilities necessary to perform the work.
 - vi. Contractor/Supplier shall provide evidence of five (5) years of financial stability. Submittals can be the most recent audited financial statement, current balance sheet, annual report, or a letter of credit from the Contractor/Supplier's bank which includes the duration of professional relationship, lending experience, and average balance.
- B. Refer to drawing details for dimensions and installations.
- C. See below for precedent images of raised boardwalk ramp and stairs system.



- D. The general specifications for the boardwalk is as follows:
- a. Pre-Engineered raised boardwalk and Stair system.
 - b. System to be prefabricated and test assembled off-site at the manufacturing plant.
 - c. Boardwalks and stairs shall be shipped to the site and assembled into place. Boardwalks and Stairs shall be installed overtop of existing terrain with minimal disturbance to the ground plane.
 - d. Boardwalks and Stairs shall have railings infill panels that meet all regulations and applicable codes. Boardwalks and Stairs shall have a minimum 75-year warranty on the metal framing, unlimited workmanship warranty and a 40-yr warranty on the decking material
- E. Materials:
- a. All frames must meet or exceed International Building Code requirements of 100psf load capacity.
 - b. Galvanized structural steel frame sections constructed from ASTM A500 Structural Steel.

- c. Frame connections to be fabricated from 1/4" A36 Structural Steel.
- d. Legs and leg-sleeves to be fabricated from ASTM A500 Structural Steel pipe.
- e. Entire post-fabrication frame assembly to be hot dipped galvanized (HDG) with a minimum of 3.9 mill thickness of zinc based galvanizing.
- f. All post-galvanized frame assemblies must be hand rasped and free of any sharp edges without compromising the galvanized integrity.
- g. All decking must meet or exceed International Building Code requirements of 100psf load capacity.
 - i. Plastic Decking - high-density polyethylene (HDPE) continuous construction plastic. Size either 2" x 6" or 5/4" x 6" HDPE from 100% recycled plastic.
- h. Frame sections are to be adjustable and leveling. Height adjustments are to be constrained with a 3/8 set bolt and 2-1/4 self-tapping screws per leg.
- i. All boardwalk surfaces are to be ADA compliant

F. Walkway:

- a. Walkways assembled from prefabricated modular sections that are 74.5" long by varying widths per plan. Each modular section consists of a frame and deck section that are pre-fabricated according to project specifications and ready to install upon delivery. Frames are pre-fabricated galvanized structural steel and supported by non-penetrating adjustable leg.
- b. Complete deck panels are pre-fabricated to match specific frames and are constructed from (2"x6" deck boards or other as specified).
- c. Each adjustable leg, two per frame section, consists of a steel leg sleeve and steel leg plate that rests on a variable sized pan-foot based on specific ground bearing capacity. No ground penetration is necessary, while supporting a live load capacity of 100 lbs/sq. ft.

G. Locking System

- a. The locking system consists of two sets of complementary lugs; a male set on the back end of an installed frame and a female set on the front of a frame being added to the walkway.
- b. Once two frames are connected to each other with the locking system, the hinged connection point provides the strength and stability of one contiguous system. Hinged connection must remain flexible enough to follow the contours of the terrain and to accommodate terrain changes up to ADA slope allowances or during freeze/thaw cycles.
- c. The locking system must allow for a top-down installation method in which crews use an installed, modular walkway section as a platform for moving materials and installing the next section.
- d. Hinge system must be removable post installation to allow for maintenance or right-a-way access.
- e. Frame section headers are each supported by a two truss systems to provide redundancy for frame-to-frame deflection. Truss plates are made from 1/4 HSS, A36 structural steel.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. The CONTRACTOR shall be solely responsible for all installation permits, safety, and environmental concerns.
- B. The installation shall be handled directly by the manufacturer or by a factory certified installation subcontractor.
- C. All materials and construction practices for foundation, railing, and decks, are to be installed per local codes and industry standards.
- D. Installed products are to be done so in accordance with manufacturer's instructions and recommendations to maintain warranty.
- E. Leg/pile locations must be determined suitable and adequate before installation.

3.02 CLEANING, REPAIR AND PROTECTION

- A. Repair minor damages to eliminate all evidence of repair. Remove and replace work that cannot be satisfactorily repaired. All site improvements damaged by the contractor will be restored to their original state at their own cost.
- B. Provide temporary protection to ensure that the work will be without dirt, stains, damage or deterioration at time of final acceptance. Clean up stains and spills as they occur. Remove protections and clean as necessary immediately before final acceptance.
- C. Upon completion of the work and before acceptance, the Contractor shall remove and dispose of in an approved manner all surplus materials, rubbish, etc. which the Contractor may have accumulated during the course of the work and shall leave the site in a clean and orderly condition. The Contractor shall not abandon any material at or near the site regardless of whether or not it has any value.

3.03 E

END OF SECTION

SECTION 328400
IRRIGATION SYSTEM

PART 1 – GENERAL

1.1 GENERAL REQUIREMENTS

- A. Include GENERAL CONDITIONS and applicable parts of Division 1 as part of this Section.
- B. Coordinate work of this Section with other underground utilities and with trades responsible for their installation. Refer to respective drawings pertaining to other work.

1.2 WORK TO BE DONE

- A. Work to be done includes furnishing labor, materials, equipment and services required to complete the irrigation work indicated on the drawings, as specified herein, or both.
- B. Point of connection shall be to the 4-inch ductile iron water main approximately where indicated on the drawings.
- C. Electrical point of connection shall be a 120-volt, 20-amp, hard wired electrical circuit for the irrigation controller located beside the irrigation water supply enclosure where indicated on the drawings.
- D. Drawings and specifications must be interpreted and are intended to complement each other. Furnish and install parts, which may be required by the drawings and omitted by the specifications, or vice versa, just as though required by both. Should there appear to be discrepancies or question of intent, the matter shall be referred to the Owner's Representative for decision, and his interpretation shall be final, conclusive and binding.
- E. Necessary changes to the drawings to avoid any obstacles shall be made with the approval of the Owner's Representative.
- F. Trench excavation, backfilling and bedding materials, together with the testing of the completed installation shall be included in this work.
- G. Work shall be constructed and finished in every respect in a good, workmanlike and substantial manner, to the full intent and meaning of the drawings and specifications. Parts necessary for the proper and complete execution of the Work, whether the same may have been specifically mentioned or not, or indicated on the drawings, shall be done or furnished in a manner corresponding with the rest of the work as if the same were specifically herein described.
- H. Record drawing as well as Operating & Maintenance Manual generation, in accordance to these specifications shall be included in this work.

1.3 SCOPE

- A. Irrigation system shown on the drawings and described within these specifications represents a single controller, athletic field irrigation system supplied from potable water. The system is designed for 150 gallons per minute at 85 psi dynamic pressure at full system flow.

1.4 RELATED WORK

- A. Carefully examine the Contract Documents for requirements that affect the Work of this Section.
 - 1. Electrical: Division 26
 - 2. Earthwork: Division 31
 - 3. Site Improvements: Division 32
 - 4. Planting: Section 329000
 - 5. Utilities: Division 33

1.5 ORDINANCES, PERMITS AND FEES

- A. Work under this Section shall comply with ordinances and regulations of authorities having jurisdiction.
- B. Permits, tests and certifications required for the execution of Work under this Section shall be obtained and paid for.
- C. Furnish copies of permits, certifications and approval notices to the Owner's Representative prior to requesting payment.

1.6 EXAMINATION OF CONDITIONS

- A. Be fully informed of existing conditions on the site before submitting bid, and be fully responsible for carrying out work required to fully and properly execute the Work of the Contract, regardless of the conditions encountered in the actual Work. No claim for extra compensation or extension of time will be allowed on account of actual conditions inconsistent with those assumed, except those conditions described in the GENERAL CONDITIONS.

1.7 QUALITY ASSURANCE

- A. Installer: A firm which has at least five (5) years' experience in work of this type (athletic fields) and size as required by this Section and which is acceptable to the Owner's Representative.
- B. References: Supply five (5) references for work of this type and size with the bid including names and phone numbers of contact person(s).
- C. Applicable requirements of accepted Standards and Codes shall apply to the Work of this Section and shall be so labeled or listed:
 - 1. American Society for Testing & Materials (ASTM)
 - a. ASTM: D1784 Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
 - b. ASTM: D1785 Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and CI200.
 - c. ASTM: D2464 Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
 - d. ASTM: D2466 Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
 - e. ASTM: D2855 Standard Practice for Making Solvent-Cemented Joints with PVC Pipe and Fittings
 - f. ASTM: B43-98 Brass Pipe.
 - g. ASTM: A536 Ductile Iron Castings
 - h. ASTM: D2564 Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Pipe System.
 - i. ASTM: F477 Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

2. National Standard Plumbing Code (NSPC)
3. National Electric Code (NEC)
4. National Sanitary Foundation (NSF)
5. American Society of Agricultural and Biological Engineers (ASABE)
6. Underwriters Laboratories, Inc. (UL)
7. Occupational Safety and Health Administration (OSHA)
8. American Society of Irrigation Consultants (ASIC)

1.8 TESTS

- A. Observation: Owner's Representative will be on site at various times to ensure the system is being installed according to the specifications and drawings.
- B. Coverage Test: After completion of the system, test the operation of entire system and adjust sprinklers as directed by the Owner's Representative. Demonstrate to the Owner's Representative that irrigated areas are being adequately covered. Furnish and install materials required to correct inadequacies of coverage due to deviations from the drawings or where the system is obviously inadequate or inappropriate. (See Part 3 - Execution).
- C. Owner's Representative shall be notified 7 days in advance for observations.

1.9 SUBMITTALS

- A. Provide electronic copies of product specification sheets on proposed equipment to be installed to the Owner's Representative for approval prior to the start of work, in accordance with the parameters of Division-1. Work on the irrigation system may not commence until product sheets are submitted and approved. Submittals shall be marked up to show proper nozzles, sizes, flows, etc. Equipment to be included:
 1. Sprinklers
 2. Valves: Manual and Automatic
 3. Controller
 4. Decoders
 5. Valve Boxes
 6. PVC Pipe and Fittings
 7. Communication Cable and Connectors
 8. Quick Coupling Valves
 9. Weather Sensor
 10. Air Release Valves
 11. Flow Sensor
 12. Flow Sensor Cable
 13. Master Valve
 14. Swing and Swivel Joints
 15. Lightning Arrestors
 16. Grounding Equipment
 17. Water Meter
 18. Backflow Prevention Device
 19. Water Supply Enclosure
 20. Miscellaneous Materials
- B. Project Record Documents:
 1. Provide and keep up-to-date a complete redlined record set of drawings of the system as the project proceeds. Drawings shall be corrected daily, showing every change from the original drawings and specifications. Record drawings shall specify and exactly locate sprinkler type; pop up height and nozzle for each sprink-

ler installed. Each valve box location to be referenced by distance from a minimum of two permanent locations. Controller, weather sensor, quick coupling valves, isolation and electric valves, air release valves and other equipment shall be indicated on the drawings. Communication cable routing, size and splices shall be indicated. Mainline pipe, lateral pipe and communication cable route shall have three (3) distinctly different graphic symbols (line types). This redlined record set of drawings shall be kept at job site and shall be used only as a record set.

2. Make neat and legible notations on this record set of drawings daily as the Work proceeds, showing the Work as actually installed. For example, should a piece of equipment be installed in a location that does not match the plan, indicate that equipment in a graphic manner in the location of installation and so as to match the original symbols as indicated in the irrigation legend. Should the equipment be different from that specified, indicate with a new graphic symbol both on the drawings and the irrigation legend. The relocated equipment dimensions and northing and easting coordinates should then be transferred to the appropriate drawing in this record set of drawings at the proper time.
3. On or before the date of final field observation, deliver corrected and completed AutoCAD computer plots of "record drawings" on vellum and AutoCAD electronic files on disk to Owner's Representative as part of contract closeout. Delivery of plots will not relieve the responsibility of furnishing required information that may have been omitted from the prints. Record drawings shall not be marked up design drawings. Record drawings shall be on Contractor's title block with installed, not proposed irrigation information.

1.10 DELIVERY, STORAGE AND HANDLING

- A. Store and handle materials in compliance with manufacturer instructions and recommendations. Protect from possible damage. Minimize on-site storage.

1.11 GUARANTEE

- A. Obtain in the Owner's name the standard written manufacturer's guarantee of materials furnished under this Section where such guarantees are offered in the manufacturer's published product data. These guarantees shall be in addition to, and not in lieu of, other liabilities that the Company performing the work under contract may have by law.
- B. In addition to the manufacturers guarantees, the irrigation system shall be warrantied, both parts and labor for a period of two (2) years from the date of acceptance by the Owner.
- C. As part of the two-year warranty, winterizations and spring start-ups for the irrigation system shall be performed.
- D. Should any problems develop within the warranty period because of inferior or faulty materials or workmanship, they shall be corrected to the satisfaction of the Owner's Representative at no additional expense to the Owner.
- E. A written warranty showing date of completion and period of warranty shall be supplied upon completion of the project.

1.12 COORDINATION

- A. Work shall be coordinated closely with the Owner's Representative to avoid misunderstandings and to efficiently bring the project to completion. Owner's Representative shall be notified as to the start of work, progression and completion, as well as any changes to the drawings before the change is made. Coordinate work with those of other trades.

- B. Be responsible and pay for damage to other work caused by work or workmen. Repair such damage as directed by the Owner's Representative.

1.13 MAINTENANCE AND OPERATING INSTRUCTIONS

- A. Include in Bid an allowance for four (4) hours of instruction of Owner and/or Owner's personnel upon completion of check/test/start-up/adjust operations by a competent operator (Owner's Representative office shall be notified at least one (1) week in advance of check/test/start-up/adjust operations).
- B. Upon completion of work and prior to application for acceptance and final payment, a minimum of three (3), three ring, hard cover binders titled MAINTENANCE AND OPERATING INSTRUCTIONS FOR NORTHEAST METROPOLITAN REGIONAL VOCATIONAL HIGH SCHOOL IRRIGATION SYSTEM, shall be submitted to the Owner's Representative office. After review and approval, the copies will be forwarded to the Owner. Included in the Maintenance and Operating binders shall be:
 - 1. Table of Contents
 - 2. Written description of Irrigation System.
 - 3. System drawings:
 - a. One (1) copy of the original irrigation plan;
 - b. One (1) copy of the Record Drawing;
 - c. One (1) reproducible of the Record Drawing;
 - d. One (1) copy of the controller valve system wiring diagram
 - 4. Listing of Manufacturers.
 - 5. Manufacturers' data where multiple model, type and size listings are included; clearly and conspicuously indicating those that are pertinent to this installation.
 - a. "APPROVED" submittals of irrigation equipment;
 - b. Operation: User's Manuals (controller, valves, etc.)
 - c. Maintenance: including complete troubleshooting charts.
 - d. Parts list.
 - e. Names, addresses and telephone numbers of recommended repair and service companies.
 - 6. A copy of the suggested "System Operating Schedule" which shall call out the controller program required (zone run time in minutes per day and days per week) in order to provide the desired amount of water to each area under "no-rain" conditions.
 - 7. Winterization and spring start-up procedures.
 - 8. Guarantee data.

1.14 PROCEDURE

- A. Notify public utility owners concerned, of the time and location of any work that may affect them. Cooperate and coordinate with them in the protection and/or repairs of any utilities.
- B. Provide and install temporary support, adequate protection and maintenance of structures, drains, sewers, curbs and other obstructions encountered. Where grade or alignment is obstructed, the obstruction shall be permanently supported, relocated, removed or reconstructed as directed by the Owner's Representative.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Materials to be incorporated in this system shall be new and without flaws or defects and of quality and performance as specified and meeting the requirements of the system. Material overages at the completion of the installation shall be removed from the site.
- B. Material substitutions from the irrigation products described in these specifications and shown on the drawings shall be made without prior approval and acceptance from the Owner's Representative.

2.2 PVC IRRIGATION PIPE

- A. Pipe shall bear the following markings: Manufacturer's name, nominal pipe size, schedule or class, pressure rating in psi, and date of extrusion.
- B. PVC pipe 2-1/2 inches and below shall be PVC, Class 200, Type 1120, SDR 21, solvent-weld PVC, conforming to ASTM No. D2241 as manufactured by Ipex, JM Eagle, Silverline or equal.
- C. Irrigation pipe 3-inches and above in size shall be PVC, Class 200, Type 1120, SDR 21, gasketed joint PVC, conforming to ASTM No. D1784 as manufactured by Ipex, JM Eagle, Silverline or equal.

2.3 PVC PIPE SLEEVES

- A. Pipe sleeves beneath non-soil areas shall be PVC, Class 200 water pipe as manufactured by Ipex, National, JM Eagle or equal. Sleeve size shall be as indicated on the drawings. Minimum sleeve size to be 3-inch.

2.4 ELECTRICAL CONDUIT

- A. Conduit for wire/cable beneath non-soil areas shall be 2-inch PVC, SCH-40 conduit with solvent-weld joints, as manufactured by Cresline, Carlon, JMM, or equal.
- B. Sweep ells shall be standard electrical type PVC schedule 40 long sweep elbows. Cap sweep ell with tri-plug with the ring for securing nylon pull rope.
- C. Conduit for above ground wiring to rain sensor and controller shall be Schedule 40 rigid conduit.

2.5 PVC IRRIGATION FITTINGS

- A. Fittings for solvent weld PVC pipe, 2-1/2 inch and smaller in size, shall be Schedule 40 solvent weld PVC fittings as manufactured by Dura, Lasco, Spears or equal.
- B. Fittings shall bear manufacturer's name or trademark, material designation, size, and applicable I.P.S. schedule.
- C. PVC threaded connections in and out of valves shall be made using Schedule 80 toe nipples and Schedule 40 couplers or socket fittings. Schedule 40 threads will not be approved for installation.
- D. PVC solvent shall be NSF approved, for Type I and Type II PVC pipe, and Schedule 40 and 80 fittings. Cement is to meet ASTM D2564 and FF493 for potable water pipes. Cement shall be medium set not fast (no wet and dry or hot). PVC solvent cement shall be Rectorseal Gold, IPS Weld-ON 711, Oatey Heavy Duty Cement or equal, and shall be used in conjunction with the

appropriate primer. Primer shall be NSF approved, and formulated for PVC and CPVC pipe applications. Primer is to meet ASTM F 656. Primer shall be Rectorseal Jim PR-2, IPS Weld-ON P-70, Oatey Primer for PVC and CPVC, or equal. Clear primers and cements are no acceptable.

- E. Nipples to be schedule 80 PVC.
- F. Fittings for PVC directional changes, pipe reductions and plugs 3- inch and larger in size shall be deep bell push-on gasket, epoxy coated inside and out, joint ductile iron fittings for PVC pipe. Fittings shall be manufactured of ductile iron, grade 70-55-05 in accord with ASTM A536 and gaskets shall meet ASTM F477. Fittings shall be as manufactured by Harrington Corporation - Harco, or equal.
- G. Mainline pipe to zone valve / lateral pipe connections, Harco or equal push-on gasket joint ductile iron swivel service tees, epoxy coated inside and out, shall be used. Saddles, (strap, bolt down or snap) will not be approved for installation.

2.6 SMALL ROTARY SPRINKLERS

- A. Small rotary sprinklers shall be gear-driven, rotary type sprinklers, designed for in-ground installation with integral check valves and in-riser flow shut-off capability. Sprinkler shall be capable of covering a 25-44-foot radius and flow range of 0.9-7.0 gpm at 50-55 pounds per square inch of pressure. Sprinklers shall have a one hundred percent warranty for two years' minimum against defects in workmanship.
- B. Nozzle assembly shall elevate minimum four inches when in operation and retraction shall be achieved by a stainless-steel spring. Riser assembly shall be stainless-steel. A nozzle wiper seal shall be included in the sprinkler for continuous operation under the presence of sand and other foreign material.
- C. Sprinkler parts shall be removable through the top of the unit through the removal of a heavy-duty threaded cap. The sprinkler shall have a three quarter-inch (3/4") IPS water connection on the bottom of the sprinkler.
- D. Sprinklers shall be manufactured by Rain Bird model 5004-SS-SAM or Hunter Industries model I20-04-SS or equal w/MPR nozzles.
- E. Approved Performance Chart (18 and 25 Foot Spacing)

Model	Pressure	Arc	Nozzle	Flow	Radius
Rain Bird 5004-PL-SAM	45 psi	90 Deg.	MPR 25Q	1.0	25'
Rain Bird 5004-PL-SAM	45 psi	180 Deg.	MPR 25H	1.98	25'
Rain Bird 5004-PL-SAM	45 psi	360 Deg.	MPR 25F	3.82	25'
Hunter I20-04	45 psi	90 Deg.	MPR 25Q	1.0	25'
Hunter I20-04	45 psi	180 Deg.	MPR 25H	1.98	25'
Hunter I20-04	45 psi	360 Deg.	MPR 35F	3.82	25'

2.7 LARGE ROTARY SPRINKLERS

- A. Large rotary sprinklers shall be gear-driven, rotary type with drain check valve and stainless-steel riser designed for in-ground installation. The nozzle assembly shall elevate three inches when in operation and retraction shall be achieved by a stainless-steel spring. Check valve shall be capable of holding up to 10 feet of elevation. Sprinkler shall be capable of covering a 49-61-foot radius and flow range of 7.5 to 15.7 gpm at 60 pounds per square inch of pressure.
- B. Sprinkler parts shall be removable through the top of the unit by removing a heavy-duty threaded cap. The sprinkler shall have a one- inch (1") IPS water connection on the bottom of the sprinkler.
- C. Sprinklers shall be manufactured by Hunter Industries model I25-04-SS, Rain Bird model 8005-SS or equal.
- D. Approved Performance Chart (45' Spacing):

Model	Pressure	Arc	Nozzle	Flow	Radius
Rain Bird 8005-SS	60 psi	90 Deg.	5	5.3	45'
Rain Bird 8005-SS	60 psi	180/360 Deg.	8	9.2	50'
Hunter I25-04-SS	60 psi	90 Deg.	5	5.3	45'
Hunter I25-04-SS	60 psi	180/360 Deg.	8	9.2	50'

- E. Approved Performance Chart (55 Foot Spacing):

Model	Pressure	Arc	Nozzle	Flow	Radius
Rain Bird 8005-SS	60 psi	90 Deg.	8	8.4	49'
Rain Bird 8005-SS	60 psi	180/360 Deg.	12	12.0	59'
Hunter I25-04-SS	60 psi	90 Deg.	8	9.2	50'
Hunter I25-04-SS	60 psi	180/360 Deg.	18	15.7	59'

2.8 ELECTRIC CONTROL VALVES

- A. Electric control valves shall be one, one and one half and two-inch remote control, diaphragm type, fiberglass or reinforced nylon body plastic valves with manual flow control, manual bleed screw, dirty water filter and 200 psi pressure rating.
- B. Valves shall be manufactured by Rain Bird model PESB, Hunter Industries model ICV or equal.

2.9 VALVE BOXES

- A. Valve boxes shall be manufactured from unformed resin with a tensile strength of 3,100-5,500 psi conforming to ASTM D638. Boxes shall be green or black in color.

- B. Valve box for mainline ringtite isolation gate valves shall be 5-1/4-inch round valve boxes with poly-iron (detectable) sleeves and plastic cover. Top piece shall be 15-1/2 inches long and bottom piece 24 inches. Top shall turn on bottom section to allow for adjustment to grade. Boxes to be as manufactured by Highline Products. "T" handle wrench must fit well inside of box.
- C. Valve boxes for small isolation valves and quick coupling valves shall be 10-inch round valve boxes with metal detection, T-top lids and bolt down covers.
- D. Valve boxes for single 1-inch and 1-1/2-inch electric valves with isolation, flow sensor, master valves shall be 12-inch standard valve boxes with metal detection, T-top lids and bolt down covers.
- E. Valve boxes for single 2-inch, dual 1-inch and dual 1-1/2-inch electric valves with isolation shall be 18-inch jumbo valve boxes with metal detection, T-top lids and bolt down covers. When multiple 1 and 1-1/2 inch electric valves with isolation are installed in the same area, they are to be installed no more than two (2) valves per box in an 18-inch standard box. 2-inch electric valves with isolation shall have a maximum of one valve in an 18-inch jumbo valve box.
- F. Valve boxes for wire/communication cable splices shall be 10-inch round valve boxes with detectable disks, T-top lids and bolt down covers. Lids shall be gray in color.
- G. Valve box extensions shall be provided and installed as required for proper box depth. Valve box extensions shall be made by the same manufacturer as the box.
- H. Valve boxes shall be manufactured by Dura Products, Highline Products, Olde Castle Specification Grade or NDS Pro Series.
- I. Grated covers for ground rods and plates shall be 4-inch round, green plastic as manufactured by NDS or equal with detection.

2.10 AUTOMATIC CONTROLLER

- A. Controller shall be electronic in construction with capability of 1 second to 12 hour run times per zone. Controller to have minimum 32 independent programs, 20 station simultaneous operation, auto/off switch and be capable of manual, semi-automatic and automatic operation. Controller shall have water budgeting feature, cycle and soak feature, sensor input terminal, locking, weather resistant stainless-steel cabinet and internal transformer. Terminal strip connection shall be easily accessible. The controller shall be U.L. listed, 120-volt, 60 Hertz, A.C. type.
- B. Controller shall have flow monitoring and flow management capabilities with compatible flow sensor connection. Controller shall be capable of automatic flow learning per station and have station level flow diagnostics and alarm shutdown.
- C. Controller shall have 5-year warranty.
- D. Controller shall be as manufactured by Hunter Industries, model A2C-1200-75D-M with Hunter Solar Sync (weather sensor) or approved equal.

2.11 SURGE ARRESTOR (CONTROLLER)

- A. Modular surge arrester shall be a single phase, two pole arrester designed to protect single or split phase 120 volt or 120/240-volt electrical systems. Electrical connections shall be embedded in a UL recognized epoxy to seal and protect them from moisture and corrosion.

- B. Surge arrestor shall be molded from weather and UV resistant polycarbonate, complying with the UL Standard for flame and strength resistance.
- C. Surge Arrester shall be manufactured by Paige Electric, model 250090LED with mounting bracket.

2.12 DECODERS

- A. Decoders shall be installed between controller and the electric control valves to provide the opening and closing signal for individual valves. Decoder shall be available in 1, 2 or 4-station devices. 6 station decoders shall not be used. Decoder shall have a unique serial number and controllers-assigned address to identify it in the network.
- B. Decoder shall be manufactured by Hunter Industries, model ICD-XX or approved equal.
- C. Flow sensor decoder shall be Hunter ICD-SEN or approved equal.

2.13 WEATHER SENSOR

- A. Controller shall be able of accepting weather data from an on-site weather sensor and using this data to automatically adjust the irrigation schedule. Sensor shall have rain and freeze shutoff.
- B. Weather sensor shall be polycarbonate in construction with adjustable interruption point and metal extension arm. Weather sensor shall operate up to 200 feet from controller.
- C. Weather sensor shall be manufactured by Hunter Industries, model Solar Sync or approved equal.

2.14 CABLE

- A. Valve control wire from the controller to the decoder shall be through a #14/#14 AWG, 2-wire path. Wiring shall be polyethylene double-jacketed or UF-B UL PVC double-jacketed two-conductor solid copper designed for direct burial systems. Connections shall be installed as per their manufacturers' instructions. Cable shall be manufactured by Paige Electric P7354D or approved equal.
- B. In-ground cable connections shall be UL listed (486D), manufactured by Paige, 3M, model DBR/Y-6 splice kits or approved equal. Cable/wire splices shall be made in valve boxes, electrical junction boxes, at the controller or at valves. Connections shall be installed as per their manufacturers' instructions.
- C. Cable type and method of installation shall be in accordance with local codes for NEC Class II circuits of 30-volt A.C. or less.
- D. Wiring shall be in strict accordance with national, state and local electrical codes.

2.15 COMMUNICATION CABLE CONTROLLER TO FLOW SENSOR

- A. Communication cable from the controller to flow sensor shall be jacketed, four conductor, two pair cable. The cable shall be suitable for direct burial in the earth and also may be installed in ducts or conduits.
- B. Conductors shall be high density insulated tin coated copper conductors. Conductors shall have a 0.00235-inch aluminum/mylar shield helically applied and a #20 AWG drain wire to drain off

electrical, magnetic or RF interference. The cable shall be rated 600 volts. The four conductors shall be seven strand, #18 AWG, 0.015 high density PE insulation wall.

- C. The two pair shall be color coded red/black and blue/orange and shall be soft annealed tin coated copper conforming to ASTM B-33. Insulation shall be high density polyethylene conforming to ICEA S-56-434.
- D. Outer jacket shall be 0.045-inch polyethylene conforming to ICEA S-61-402. The communication type cable shall be marked on the jacket as follows: "2 Pr #18 AWG Shld D/B Paige P7171D".
- E. Wire shall be as manufactured by Paige Electric, P7171D or approved equal.

2.16 FLOW SENSOR

- A. Flow sensor for potable water supply shall be 3-inch, with 150 psi pressure rating. Sensor shall have flow range of 6 to 300 gpm and be installed in a PVC saddle tee. Output shall be two wire standard pulse. Flow sensor shall be as manufactured by Creative Sensor Technologies, model CSI-FS1-S30-001 w/saddle.

2.17 NORMALLY OPEN MASTER VALVE

- A. Normally open master control valve shall be in 3-inch in size. Valve shall have no minimum flow feature.
- B. Valve shall come with two-piece upper diaphragm and lower seat assembly. Valve shall operate within a pressure range of 20psi-200psi and have an in-rush current of 0.45amps and a holding current of 0.30 amps at 24VAC.
- C. Valve shall be designed with removable filter and metering rod assembly and non-continuous flow through the solenoid. Rubber parts shall be EPDM rubber parts.
- D. Normally open master valve shall be manufactured by Buckner/Superior, Storm Manufacturing Group, Inc., model 3300300 or approved equal.

2.18 QUICK COUPLING VALVES

- A. Valve body shall be of cast brass construction with a working pressure of 125 psi. The valve seat disc plunger body shall be spring loaded so that the valve is normally closed under conditions when the key is not inserted.
- B. Top of the valve body receiving the key shall be equipped with ACME threads and smooth face to allow the key to open and close the valve slowly. The quick coupling valve shall be equipped with a vinyl cover.
- C. Valve body construction shall be such that the coupler seal washer may be removed from the top for cleaning or replacement without disassembling any other parts of the valve.
- D. Keys shall be ACME with 1-inch male thread and 3/4-inch female thread at the top.
- E. Quick coupling valves, keys and swivels shall be manufactured by Toro models 100-ATLVC, 100-AK and 075-MHS, Hunter Industries, model HQ-44RC-AW, HK-44A and HS-1 or equal.

2.19 CONTROLLER ENCLOSURE

- A. Enclosure shall be vandal and weather resistant in nature manufactured entirely of 304-grade stainless steel. The main housing door shall be louvered at the bottom and equipped with a hollow center thermoplastic door seal. The entry lip shall be louvered on the backside. Filter screens shall cover louvers. The top entry lid shall have two gas springs, for easy access, a continuous stainless-steel piano hinge, and a three-point locking mechanism with provisions for padlock. Removable stainless-steel tray shall be provided and installed for the mounting of electronics and other equipment.
- B. Enclosure shall be a NEMA 3R Rainproof Enclosure as listed by Underwriters Laboratories, Inc.
- C. Controller enclosure shall be 16 inches wide x 15.5 inches deep x 38 inches tall, as manufactured by Strong Box, model SB-16SS with OPT-HUN-ACC mounting tray.

2.20 ISOLATION VALVES

- A. Isolation ball valves for air vacuum/release valves shall be of bronze construction, US Manufacture, minimum 3/4 port, 600 WOG with stainless steel handle and chrome plated ball. Ball valves are to be as manufactured by Apollo, Boston, Watts or equal.
- B. Isolation gate valves, where indicated on the drawings, for drains and 1-inch athletic field electric valves shall be of bronze construction, threaded, US Manufacture, 600 WOG with bronze cross handle and 200 psi rating. Gate valves to be as manufactured by Apollo model 102-T or Nibco model T-113-K.
- C. Isolation gate valves for 1-1/2-inch and 2-inch athletic field electric valves taps shall be angle globe valves with a minimum Cv of 100. Ends shall be male swivel with one bolt machined restraint. Body, bonnet, bonnet bolts, seal assembly, side outlet plug and cross handle assembly shall be 316 stainless steel, ASTM A351. Stem shall be of bronze construction, ASTM B62-C83600. Seal shall be EPDM rubber, ASTM D2000. Valves shall have 200 psi rating. Gate valves to be as manufactured by the Harrington Corporation or equal. Valves shall 2x6x15 gasket x male swivel.
- D. Isolation valves 3 inches and larger in size shall be cast iron epoxy coated inside and outside, ringtite valves, 200 psi rated, ductile iron gland flange, bronze stem-seal replaceable under pressure, stainless steel stem, US Manufacturer, 2-inch operating nut and resilient wedge replaceable disc conforming to AWWA C-509 as manufactured by Waterous 500 Series, Clow 2630 Series or Kennedy Ken-Seal Series.

2.21 SWING JOINTS

- A. 3/4-inch sprinklers shall be installed on prefabricated PVC swivel joints, minimum 315 psi rating and minimum length of 12 inches. PVC swivel joints shall be as manufactured by Lasco, Spears or equal.
- B. Large rotary sprinklers shall be installed on 1-inch prefabricated PVC unitized swing joint assemblies with double O-ring seals, minimum 315 psi rating and minimum length of 12 inches. Prefabricated PVC swing joints shall be as manufactured by Dura, Lasco or Spears.
- C. Quick coupling valves to be installed on 1-inch prefabricated PVC unitized swing joint assemblies with double O-ring seals, minimum 315 psi rating and minimum length of 12 inches with brass insert and stabilizer (unless stabilizer is an integral part of the quick coupling valve). Prefabricated PVC swing joints shall be as manufactured by Dura, Lasco or Spears.

2.22 IDENTIFICATION TAGS

- A. Electric valves shall have ID tags attached. ID tags shall be manufactured from Polyurethane Behr Desopan. Provide one tag for each valve. Each tag shall provide valve and station ID information.
- B. Tags shall be as manufactured by Paige Electric, T. Christy Enterprises or equal.

2.23 BRASS FITTINGS AND NIPPLES

- A. Brass/bronze fittings and nipples shall be used for air vacuum/release valve discharge and quick coupler keys and as otherwise detailed. Brass/bronze fittings shall be cast conforming to ASA B16.15. Threads shall conform to ASA B2.1.

2.24 COMBINATION AIR VACUUM/RELEASE VALVE

- A. Combination air vacuum/release valve to be Crispin, Model IC-10 or equal with 1-inch NPT inlet and a 1-inch air and vacuum outlet with a 3/32-inch pressure air release orifice. The valve body shall be cast iron body with stainless steel internals and float and Buna-N seating material. The valves shall exhaust large quantities of air on system start-up and allow air to re-enter the pipeline when the line is being emptied or drained. The valves shall also automatically vent air that accumulates while the system is under pressure.
- B. A 1-inch ball valve and 1-inch bronze wye strainer shall be installed below the air/vacuum release valve. Wye strainer shall utilize a 1/2-inch boiler drain for cleaning. See detail.
- C. Release valve outlet shall be piped with brass elbows and nipples to direct the air out of the valve as shown on the detail.

2.25 WATER METER

- A. 3-inch water meter shall be Neptune compound meter w/ 3-inch strainer as approved by the Town of Wakefield Water Department.

2.26 BACKFLOW PREVENTION DEVICE

- A. Reduced pressure backflow prevention device shall be 3-inch, Watts LF909 w/NRS gate valves as approved by the Town of Wakefield Water Department.

2.27 WATER SUPPLY ISOLATION VALVES

- A. Isolation valve for water supply shall be flanged resilient wedge ductile iron gate valve with non-rising stem, US Manufacture.

2.28 WATER SUPPLY ENCLOSURE

- A. Enclosure shall be of a vandal and weather resistant nature manufactured entirely of aluminum with 1-1/2-inch insulated aluminum with locking hasp.
- B. Enclosure shall contain two (2), 120-volt, 1000-watt heaters with thermostat switch capable of maintaining 4°C (40°F) inside the enclosure when subjected to 34°C (-30°F) outside air temperature.
- C. Enclosure shall be designed to support a minimum vertical load of 100 lb./sf.

- D. Depth of water within the enclosure shall not exceed 6 inches during full flow of the backflow preventer relief discharge.
- E. Enclosure shall be designed to be accessed and provide sufficient room for testing and maintenance; shop drawings shall be submitted from the manufacturer.
- F. Enclosure shall meet ASSE Standard 1060.
- G. The enclosure interior dimensions shall be 85 inches long x 55 inches wide x 57 inches tall. Unit shall be as manufactured by Hubbell Systems, Hot Box, Model HB3E-DS.

2.29 PRESSURE GAUGE

- A. Pressure gauge shall be glycerin filled with accuracy conforming to ANSI Grade B or greater. Gauges shall be provided minimum on main discharge pipe before and after wye strainer.

2.30 CONCRETE/CONCRETE BASES

- A. Concrete bases shall be standard concrete mix in accordance with ASTM C150, ASTM C-33, and ASTM C-94 with a compressive strength (28 days) of 3,000 psi.
- B. Cement concrete for thrust blocks shall be 3,000 psi, 1-1/2-inch aggregate.
- C. Concrete base for controller enclosure shall be 29-inch x 29-inch x 6 inches deep as indicated on the detail.
- D. Concrete base for water supply enclosure shall be 97 inches long x 67 inches wide x 6 inches deep.
- E. Bases shall be installed on minimum 6-inch crushed stone.

2.31 GROUNDING EQUIPMENT

- A. Grounding rod for controller shall be 5/8-inch x 10-foot copper clad, UL Listed.
- B. Grounding rods for communication cable shall be 5/8-inch x 8-foot copper clad, UL Listed.
- C. Grounding plates for communication cable to be 4-inch x 36-inch x 0.06-inch copper with integral connection of 10 feet of #10 AWG insulated, solid copper cable, UL Listed conforming to the minimum requirements of Section 250 of the National Electric Code. Connection of the cable to plate shall be performed by the plate manufacturer.
- D. Grounding plate for controller shall be 4-inch x 96-inch x 0.06-inch copper with integral connection of 25 feet of #6 AWG insulated, solid copper cable, UL Listed conforming to the minimum requirements of Section 250 of the National Electric Code. Connection of the cable to plate shall be performed by the plate manufacturer.
- E. Grounding connection to utilize an exothermic welding process, Cadweld or approved equal connector, UL Listed, Model NT1161GPLUS and straight through couplers PG11LPLUS.
- F. Grounding wire for controller shall be #6 AWG, solid, insulated copper cable.
- G. Grounding cable for communication cable shall be #10 AWG, solid, insulated copper cable.

- H. Ground enhancement material shall be PowerSet as manufactured by Loresco or approved equal, 50 lb. bags.

2.32 CRUSHED STONE

- A. 1/2-inch crushed stone shall be washed at the source facility to remove fine-grained soils and shall be well graded within the following limits:

<u>Sieve Size</u> <u>(ASTM D422)</u>	<u>Percent Passing</u> <u>by Weight</u>
3/4 inch	100
1/2 inch	90-100
3/8 inch	0-20
No. 4	0-5

2.33 SAND

- A. Shall consist of well-graded natural sand, free from organic, other weak or compressible materials, or frozen materials, conforming to the following gradation:

<u>Sieve No.</u>	<u>Percent Passing by Weight</u>
#8	100
#50	15-40
#100	2-10
#200	0-5

2.34 SPARE PARTS

- A. Supply the following tools and equipment to the Owner's Representative before final observation:
1. Two (2) wrenches or keys for disassembling and adjusting each type of sprinkler provided.
 2. Four (4) quick coupler key assemblies.
- B. Before final observation can occur, written evidence that the Owner's Representative has received the tools and equipment must be shown.

PART 3 - EXECUTION

3.1 GENERAL

- A. Before work is commenced, hold a conference with the Owner's Representative to discuss general details of the Work.
- B. Examine Contract Documents applying to this Section noting any discrepancies and bringing the same to the attention of the Owner's Representative for timely resolution.
- C. Work indicated on drawings shall be provided whether or not specifically mentioned in the specifications.
- D. If there are ambiguities between drawings and specifications, and specific interpretation or clarification is not issued prior to bidding, the interpretation or clarification will be made only by Owner's Representative, and compliance with the decisions shall be required. In the event the installation contradicts the directions given, the installation shall be corrected at no additional cost to the Owner.

- E. Verify dimensions and grades at job site before work is commenced. Do not proceed with installation of the irrigation system when it is apparent that obstructions or grade differences exist or if conflicts in construction details, legend or specific notes are discovered. Such obstructions, conflicts, or discrepancies shall be brought to the attention of the Owner's Representative.
- F. Make field measurements necessary for the work noting the relationship of the irrigation work to the other trades. Coordinate with other trades. Project shall be laid out essentially as indicated on the Irrigation Plans. Major changes shall be reviewed with the Owner's Representative prior to proceeding.
- G. Layout of sprinkler pipes indicated on drawings is diagrammatic. Location of sprinkler equipment is contingent upon and subject to integration with other underground utilities. Employ data contained in the Contract Documents and verify this information at the construction site to confirm the manner by which it relates to the installation.
- H. Coordinate installation of irrigation materials, including pipe, to avoid conflict with trees, shrubs or other plantings.
- I. During progress of work, a competent superintendent and assistants necessary shall be on site and shall be satisfactory to the Owner's Representative. Superintendent shall not be changed, except with the consent of the Owner's Representative, unless that person proves unsatisfactory and ceases to be employed. Directions given to the superintendent shall be binding.
- J. Protect installed plantings, paving, pavers, structures, walls, footings, etc. from damage. Inadvertent damage to the work of another trade shall be reported at once.

3.2 PIPE AND FITTINGS INSTALLATION

- A. Using proper equipment, excavate a straight (vertical) and true trench to a depth of 2-inch of pipe invert elevation.
- B. Loam or topsoil encountered within the limits of trench excavation for irrigation mains and branch lines shall be carefully removed to the lines and depths as shown on the drawings and stockpiled for subsequent replacement in the upper 6 inches of the trench from which it is excavated. Such removal and replacement of the quantities of loam shall be considered incidental to the irrigation system and no additional compensation will be allowed therefore.
- C. Pipe shall be laid on undisturbed trench bottom provided suitable base is available - no rock; if not, excavate to 2-inch below pipe invert and provide and install sand base or crushed stone upon which to lay pipe.
- D. Backfilling shall be accomplished as follows: backfill material shall contain no foreign matter and no rock. Carefully place material around pipe and wire and tamp in place. Remainder of backfill shall be laid-up in 6-inch (maximum) lifts and tamped to compaction with mechanical equipment. Compact backfill in trenches to dry density equal to the adjacent undisturbed soil, and conform to adjacent grades without dips, sunken area, humps, or other irregularities. Frozen material shall not be used for backfill.
- E. Clean bell and spigot ends and make gasketed joints in strict accordance with manufacturer's recommendations, making certain not to apply an excess of lubricant, and wiping off any excess lubricant from each connection. Maximum deflection per joint shall not exceed manufacturer's recommendations. Pipe insertion mark shall be visible to show the proper depth into spigot.
- F. Make solvent-weld joints in strict accordance with manufacturer's recommendations, making certain not to apply an excess of primer or solvent, and wiping off excess solvent from each

connection. Allow welded joints at least 15 minutes set-up/curing time before moving or handling. When the temperature is above 80° F, allow connections to set minimum 24 hours before pulling or pressure is applied to the system. When temperature is below 80° F, follow manufacturer's recommendations. Provide and install for expansion and contraction as recommended. Wire shall be laid in same trench as mainline and at pipe invert (see Wire Installation).

- G. Mainline pipe shall have minimum 22 inches of COVER (excavate to invert as required by pipe size). Lateral pipe shall have minimum 16 inches of COVER (PVC) and 12 inches of COVER (Polyethylene), (excavate to invert as required by pipe size).
- H. Cut plastic pipe with handsaw or pipe-cutting tool, removing burrs at cut ends. Pipe cuts are to be square and true. Bevel cut end as required to conform to Manufacturer's specifications.
- I. Every precaution shall be taken to prevent foreign material from entering the pipe while it is being placed in the trench. At times, when installation of the pipe is not in progress, the open end(s) of the pipe shall be closed by a watertight plug or other means. Pipe which cannot temporarily be joined, shall be sealed to make as watertight as possible. This provision shall apply during the lunch hour as well as overnight. Pipe not to be installed that day shall not be laid out. Should water enter the trench during or after installation of the pipe, no additional pipe may be installed or backfilled until water is removed from the trench. Pipe shall not be installed when water is in the trench, when precipitation is occurring, or when the ambient temperature is at 40° F or below. Pipe installed at temperatures below 40° F shall be removed and replaced at no cost to the Owner. PVC pipe shall be snaked in the trench to accommodate for expansion and contraction due to changes in temperature.
- J. Maintain 6-inch minimum clearance between sprinkler lines and lines of other trades. Do not install sprinkler lines directly above another line of any kind.
- K. Maintain 1-inch minimum between lines which cross at angles of 45 to 90 degrees.
- L. Throughout the guarantee period refill trenches that have settled due to incomplete compaction.
- M. Pulling of lateral pipe (no mainline) shall be allowed provided soil is suitable and specified depth of bury can be maintained.

3.3 THRUST BLOCKING

- A. Ringtite bell-end fittings and isolation valves shall be blocked with an adequately sized thrust block as per ASAE Standard S376.2 and as depicted in the details. Blocking shall be in accordance with pipe and fitting manufacturer's recommendations. Thrust blocks shall be required at changes in size and direction of bends, reducers, plugs and tees. Thrust blocks shall be installed against undisturbed soil. Concrete thrust blocks shall utilize 3,000-psi standard concrete mixture. Bricks, stones, boulders, etc. will not be accepted as thrust blocks or thrust block material. Sakrete will not be permitted as a thrust blocking material. Supply material needed for thrust blocking.
- B. Size of thrust block shall be determined by working pressure, size and type of fitting, and soil conditions. Calculate area required for concrete thrust block in contact with soil. Refer to fittings manufacturer's thrust block sizing table to determine size of thrust block for each condition.
- C. Ensure stability of thrust blocks.
- D. Under no circumstances will concrete block be approved for thrust blocks.

3.4 ELECTRICAL WIRE CONDUIT INSTALLATION

- A. Electrical conduit shall be installed in non-soil areas, as well as for above ground wiring where wire passes under or through walls, walks and paving/pavers to controller and rain sensor.
- B. Conduit shall extend 18 inches beyond edges of walls and pavement.

3.5 PIPE SLEEVING INSTALLATION

- A. Sleeving shall be installed wherever pipe is going under hardscape areas where indicated on the drawings. Minimum cover over sleeving pipe shall be 24 inches as shown on the detail.
- B. Sleeving shall extend 18 inches beyond edges of walls and pavement/pavers. Prior to the installation of irrigation pipe and wiring, the ends of sleeving shall be field marked with a vertical wood stake extending above grade to allow field location at the time of irrigation installation.
- C. Ensure required sleeving is installed prior to starting any pavement/paver operations. Review sleeve locations in the field to confirm that sleeves are properly located for the required irrigation pipe runs. In no case will saw cutting into newly installed pavements/pavers or jacking under new pavements/pavers be permitted to install sleeving which was not installed in proper sequence or in the required orientations or locations.

3.6 ISOLATION VALVE INSTALLATION

- A. Install isolation valves per details where indicated on the drawings and before each electric valve as detailed. Install isolation valves on a level crushed stone base so that they can be easily opened or closed with the appropriate valve wrench. Install specified valve box over each isolation valve.
- B. Check and tighten valve bonnet packing before valve box and backfill installation.
- C. Center equipment in valve boxes for servicing.
- D. Provide and install thrust blocks for mainline isolation valves as per details.

3.7 VALVE BOX INSTALLATION

- A. Furnish and install a valve access box for each electric valve, flow sensor, quick coupling valve, isolation valve, master valve, air vacuum/release valve, ground rod and plate and wire splice.
- B. Valve access boxes shall be installed on a minimum 4-inch crushed stone base. Finish elevation of boxes shall be at grade. Supply crushed stone and install before valve box. Crushed stone shall not be poured into previously installed valve boxes.
- C. Valve boxes shall be installed neatly. Boxes shall be parallel or perpendicular to hardscape edges and equidistance to other valve boxes installed in the same location. A sufficient amount of turf shall remain in place between each valve box and between valve boxes and hardscapes.
- D. Valve box extensions shall be provided as required on valve boxes in order to install valve box covers at grade.
- E. Valve box locations for athletic fields shall be installed minimum 15 feet from playing surfaces.
- F. Bricks, stones, etc. shall not be used to support valve boxes.

3.8 24 VOLT CONTROL VALVE INSTALLATION

- A. Control valves shall be installed on a level crushed stone base. Grade of bases shall be consistent throughout the project so that finish grades fall within the limits of work. Valves shall be set plumb with adjusting handle and bolts, screws and wiring accessible through the valve box opening. Valves shall be set in a plumb position with 24-inch minimum maintenance clearance from other equipment.
- B. Adjust zone valve operation after installation using flow control device on valve.

3.9 CABLE INSTALLATION

- A. Sufficient slack for expansion and contraction shall be maintained and wiring shall at no point be installed tightly. Provide and install an additional 8 inches to 12 inches slack at changes of direction. Cable in valve boxes shall be a sufficient length to allow the valve solenoid, decoder, splice and connections to be brought above grade for servicing. This additional slack shall be coiled for neatness in the valve box.
- B. Cable shall be laid in trenches and shall be carefully backfilled to avoid any damage to the cable insulation or wire conductors themselves. In areas of unsuitable material, the trench shall have a 2-inch layer of sand or stone dust on the bottom before the cable is laid into the trench and backfilled. The cable shall have a minimum of 22 inches of cover (See Detail). Cable not to be installed that day shall not be laid out.
- C. Service cable in connection with drawings and local codes for low voltage service. In-ground wire connections shall be waterproofed splice kits (UL 486D). Splices shall be made in valve boxes (cable runs requiring splices between valve locations shall be provided and installed in splice box-valve box shall be used). Splice locations shall be shown on the record drawings.
- D. Provide a complete diagram showing cable routing for the connections between the controller and valves. See Section 1 for the inclusion of diagram in operation and maintenance manuals.
- E. Two-wire communication cable shall be installed along mainline path and indicated on the record drawings.
- F. Cable shall not be exposed to sunlight. Cable laying out or cable rolls for future use shall be neatly coiled with UV resistant black plastic bags on a daily basis until installed.

3.10 CONTROLLER INSTALLATION

- A. Install controller in enclosure, per detail using Hunter OPT-HUN-ACC mounting tray or equal for the Strongbox or equal enclosure. Wire decoder cables and weather sensor into controller and set proper programs.
- B. Wire controller to electrical supply at controller location.
- C. Controller shall be mounted in the specified VIT Strongbox or equal stainless-steel enclosure. Wiring within the enclosure shall be neatly run, bundled, and cinched.
- D. Controller shall be installed on a new reinforced concrete base of minimum dimensions shown on the detail, poured-in-place. Expansion shields shall not be used. Contractor to use template to install poured-in-place stainless steel "J" bolts to fasten enclosure to base. Prefabricated controller base shall not be approved for installation. Controller shall be installed on the pad to allow the operator to stand on the pad in front and back of the controller during programming and maintenance.

- E. Install minimum one (1), 1-1/2-inch PVC conduit sweep ell and spool piece through controller pad as required for communication cable. Install minimum one (1), 1-1/2-inch PVC conduit sweep ell and spool piece through controller pad for #6 AWG bare copper wire. Install minimum two (1), 1-inch PVC conduit sweep ells and spool pieces through controller pad for power and flow sensor cable. Maintain required depth of bury in/out of pad.
- F. Controller power wire, decoder cable, flow sensor cable and #6 AWG bare copper wire shall be brought to the exterior through separate sleeves in the support pad. Grounding wire shall be installed through the controller concrete pad through a separate 1-1/2-inch sleeve and not through the controller enclosure.
- G. Contractor shall install control and other irrigation-related wiring.; as well as 120-volt service to controller.
- H. Above ground wire, other than in controller enclosure shall be installed in conduit.
- I. Grounding system shall be minimum as specified and installed per manufacturer's recommendations. A third party shall certify in writing after testing the results of the grounding system megging readings.
- J. Surge arrestor ground shall be installed per manufacturers installation instructions.
- K. Seal enclosure sweep holes with expandable foam insulation.
- L. Controller shall be installed level on pad and tight to the base (no gaps).
- M. Keys shall be turned over to Owner's Representative.

3.11 CONTROLLER GROUNDING INSTALLATION

- A. Controller shall include factory-installed and factory-recommended lightning protection and shall be connected to a 5/8-inch diameter x 10-foot long copper clad grounding rod with minimum #6 AWG, solid, bare copper wire and 4-inch x 96-inch x 0.0625-inch copper grounding plates as outlined below. Minimum 20-foot separation between rod and plate. Minimum 12-foot separation between controller and ground rod. Connection to rod shall be with exothermic connectors as specified. Connection to plate shall be performed by the plate manufacturer with 25-feet of bare copper wire already attached. Grounding rod is to be covered by a 4-inch round, grated top, plastic valve cover with metal detection and six inches of 4-inch drainage pipe. Plate shall be installed in ground enhancement material. Plate shall be covered with 4-inch plastic grated cover with detection and minimum 36 inches of 4-inch drainage pipe. Ground rod and plate shall be UL listed.
- B. Controller shall be grounded to one rod and one plate. 10-foot rod shall be installed penetrating into the soil to its full length. Plate shall be installed at a 36-inch depth with 50 lbs. of ground enhancement material spread evenly below the plate and 50 lbs. spread evenly above the plate in accordance with manufacturer's requirements. Grounding electrodes shall be installed at least 10 feet from wires connected to the controller.

3.12 COMMUNICATION PATH GROUNDING

- A. Two-wire communication path shall be grounded at 600-foot maximum intervals, at every termination of a part of the wire path to a surge arrestor decoder where indicated on the drawings, and 50 feet from the controller. Each surge arrestor shall be connected to a 5/8-inch diameter x 8-foot long copper clad grounding rod and 4-inch x 36-inch grounding plate with minimum #10 AWG, solid, bare copper wire. Minimum 8-foot separation between rod and other equipment.

Connections to rods shall be with exothermic connectors as specified. Each grounding rod is to be covered by a 4-inch round, grated top, plastic valve cover with metal detection and six inches of 4-inch drainage pipe. Plate shall be installed at a 36-inch depth with 25 lbs. of ground enhancement material spread evenly below the plate and 25 lbs. spread evenly above the plate. Plates shall be covered with 4-inch plastic grated cover with detection and minimum 36 inches of 4-inch drainage pipe. Ground rods and plates shall be UL listed.

3.13 FLOW SENSOR AND MASTER VALVE INSTALLATION

- A. Flow sensor shall be installed where indicated on the drawings in a 12-inch rectangular valve box on a 4-inch crushed stone base. Flow sensor shall have sections of straight, uninterrupted pipe equal to ten times the pipe diameter upstream and five times the pipe diameter downstream of the sensor. Wire sensor to communication path with flow decoder. Wire connections shall be made using UL486D Listed waterproof connectors with separate wire nut and sealant filled tube that includes a locking, wire strain relief cap. Splice shall only be made at the sensor and controller.
- B. Flow sensor shall be provided and installed in accordance with manufacturer's instructions on the PVC mainline. Contractor shall be responsible for installation, hook-ups, materials, components and connection of flow sensor.
- C. Wire flow sensor communication cable to flow sensor and controller.
- D. Install master valves downstream of flow sensor where indicated on the drawings in a 12 inch standard valve box.

3.14 WEATHER SENSOR INSTALLATION

- A. Install weather sensor on side of controller enclosure as indicated on the details. Weather sensor shall be in direct contact with the weather and not in contact with the irrigation spray.
- B. Install weather sensor in sensor guard. Wire shall be through the side of the enclosure and be water sealed.

3.15 SPRINKLER INSTALLATION

- A. $\frac{3}{4}$ inch sprinklers shall be installed flush (perpendicular) to grade on PVC swivel joints.
- B. Large rotary sprinklers shall be installed flush to grade on 1-inch prefabricated PVC unitized swing joint assemblies with integral O-rings, minimum length 12 inches.
- C. Sprinklers shall not exceed maximum spacing indicated
- D. Adjust sprinkler zone after installation using flow control device on valve.

3.16 AIR VACUUM/RELEASE VALVE INSTALLATION

- A. Install air vacuum/release valves as per detail at locations shown on the drawings.
- B. Provide ball valve shut-off, boiler drain and wye strainer under air vacuum/release valves as per detail. Ball valve shut-off shall be easily accessible through the valve box. Install boiler drains on discharge of wye strainers.
- C. Drill thirty-two (32), 3/8-inch holes in air vacuum/release valve box covers for air passage.

- D. Air vacuum/release valve shall be installed straight up from mainline and not on the side.
- E. Air vacuum/release valve shall be installed at the high point of the mainline in the vicinity of where shown on the drawings.

3.17 QUICK COUPLING VALVE INSTALLATION

- A. Provide and install quick coupling valves where indicated on the drawings.
- B. Quick coupling valves to be mounted on 1-inch prefabricated PVC unitized swing joint assemblies with integral O-rings, minimum length 12 inches with brass insert and stabilizer as per details.

3.18 CHECK/TEST/START-UP/ADJUST

- A. Flushing:
 - 1. After pipe, valves, sprinkler bodies, pipes and risers are in place and connected, but prior to installation of sprinkler internals or nozzles open the control valves and flush out the system under a full head of water.
 - 2. Sprinkler nozzles shall be installed only after flushing of the system has been accomplished to the full satisfaction of the Owner's Representative.
 - 3. Flush the entire system after installation is complete and service any clogged equipment for thirty (30) days after substantial completion of the irrigation system.
- B. Testing:
 - 1. Leakage test: test lines for leaks under operating pressure. Repair leaks and re-test.
 - 2. Coverage test: perform a coverage test in the presence of the Owner's Representative (notify Owner's Representative at least seven (7) days in advance of scheduled coverage test). Representative will determine if the water coverage is complete and adequate. Readjust sprinklers or sprinkler locations as necessary or directed to achieve proper coverage.
 - 3. Testing shall be at no additional expense to the Owner.

3.19 CLEANING AND ADJUSTING

- A. At the completion of the work, parts of the installation shall be thoroughly cleaned. Equipment, pipe, valves and fittings shall be cleaned of grease, metal cuttings and sludge which may have accumulated by the operation of the system for testing.
- B. Adjust sprinklers, valve boxes and quick coupling valves to grade as required, so that they will not be damaged by maintenance operations.
- C. Continue sprinkler coverage adjustment as required by settlement, etc., throughout the guarantee period.
- D. Each control zone shall be operated for a minimum of 5 minutes and the sprinklers checked for consistency of delivering water. Adjustments shall be made to sprinklers that are not consistent to the point that they match the manufacturer's standards. Sprinklers, valves, timing devices or other mechanical or electrical components, which fail to meet these standards, shall be rejected, replaced and tested until they meet the manufacturer's standards.

3.20 ACCEPTANCE AND OPERATION BY OWNER

- A. Upon completion of the work and acceptance by the Owner, train the Owner's Personnel in the operation of the system (provide minimum 7-day written notice in advance of test). Furnish, in addition to the record drawings and operational manuals, copies of available specification sheets and catalog sheets to the Owner's personnel responsible for the operation of the irrigation system. Guarantee parts and labor for a minimum period of one (1) year from date of acceptance.

3.21 CLEAN UP

- A. Upon completion of installation work remove leftover materials and equipment from the site in a safe and legal manner.
- B. Remove debris resulting from work of this section.
- C. Regrade, lightly compact, and replant around sprinklers where necessary to maintain proper vertical positioning in relation to established grade.
- D. Fill depressions and eroded channels with sufficient soil mix to adjust grade to ensure proper drainage. Compact lightly and replant filled areas in accord with drawing and specification requirements.

END OF SECTION

SECTION 32 90 00
PLANTING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 apply to the work of this Section.

1.02 DESCRIPTION OF WORK

- A. The work of this Section consists of providing all labor, equipment, materials, incidental work, and construction methods necessary to perform all planting work and related items as indicated on the Contract Documents and as specified in this Section and includes, but is not limited to, the following:
1. Planting trees, shrubs, groundcovers, bulbs, perennials and plugs
 2. One-year plant guarantee period for all plants
 3. Inspection and acceptance
 4. Cleaning and protection
- B. Sustainable Building Requirements:
1. The Contractor is to implement practices and procedures to meet the project's sustainable performance goals, which include achieving LEED v4 Silver certification based on USGBC's "LEED Version 4 for Building Design and Construction: Schools" (LEED v4 BD+C: Schools).
 2. The work of this Section includes responding to Architect or Contractor requests for additional information or product data and may be required following initial Green Building Certification Institute (GBCI) review of LEED Application.
 3. Product substitution requests are subject to additional LEED submittal requirements including, but not limited to, Environmental Product Declarations (EPD), Health Product Declarations (HPD), and General Emissions Testing.

1.03 RELATED WORK

- A. Carefully examine the site and all of the Contract Documents for requirements that affect the work of this Section. No claim for additional costs will be allowed because of lack of full knowledge of existing conditions. Other specifications sections that directly relate to the work of this Section include, but are not limited to, the following:
1. Section 024113 - Site Preparation & Clearing
 2. Section 322000 – Earthwork
 3. Section 321612 – Asphalt Paving
 4. Section 321313 – Exterior Concrete
 5. Section 321400 – Unit Pavers
 6. Section 323000 - Site Improvements
 7. Section 328400 - Irrigation
 8. Section 329100 - Loam and Planting Soil Preparation
 9. Section 329200 - Turf and Grasses
- B. The work of this Section shall be coordinated with that of other trades affecting, or

affected by, this work, as necessary to assure the steady progress of all work of the Contract.

1. The planting subcontractor shall become fully acquainted with the nature and requirements of the project including the location of all underground utilities prior to starting the work of this Section.

1.04 REFERENCES

A. The following standards shall apply to the work on this Section.

1. American National Standards Institute (ANSI):
Z60.1 American Standard for Nursery Stock, latest edition, published by American Association of Nurserymen, (AAN).

1.05 SUBMITTALS

A. Material Samples and testing:

1. Provide full analysis of existing on-site loam, and off-site loam source from a laboratory that has been approved in writing by the Architect. Sampling and testing shall be as specified and performed under the work of Section 329100 Loam and Planting Soil Preparation.
2. Planting mulch: submit one gallon-sized Ziploc bag.
3. Provide manufacturers' certified analysis for soil amendments and fertilizers.
4. Plant materials List. Including: Scientific names of plants, size and quantity of plants available, location of nursery, and the suppliers name, phone number, address, and contact person.
 - a. Submit photographs of each plant proposed. A scale element or person of a known height shall appear in each photograph.
 - b. Submit Letter(s) of Certification from each nursery or the supplier listing the stock available for review attesting that the stock to be reviewed for selection is the specified plant stock meeting all the sizing and all other specified requirements and that these plants are free from disease, insect infestation or damage.
 - c. Based upon his review of the plant photograph submission(s) will determine if the plants are acceptable for field review at the nursery.
 - d. The Landscape Architect may, at his discretion, accept the plant material from the photograph without his inspection at the nursery if he deems it is in the best interest of the project to do so.
 - e. If the provisionally accepted plants do not meet the requirements of this specification when he reviews them on site prior to planting, remove them from the site at no additional cost to the Owner and replace with acceptable plant material.
5. Other Submittals
 - a. Schedule of Maintenance Operations and Monthly Status Report: including list of equipment, materials proposed for the job and watering schedule.

- b. Licenses, permits and insurance required by Local, the State and Federal government pertaining to maintenance work.
 - c. Monthly Record: All materials, fertilizers, insecticides and disease control chemicals used for the project. State when used and for what purpose and the rate(s) of application and the time(s) of application.
 - d. Written application recommendation by a licensed agricultural pest control advisor for all weed, pest and disease controls restricted by the State of Massachusetts proposed for this work.
 - e. Monthly record of all watering for the project.
10. At project close out: Submit a landscape maintenance manual containing all schedules, records and permits listed above, as well as a documentation of accepted condition of Planting and Lawns at Final Acceptance.

1.06 REGULATORY REQUIREMENTS

- A. Strictly comply with all applicable codes, regulations and requirements having jurisdiction.
- B. All fertilizer and pesticide applications shall be performed by a licensed applicator in strict conformance with all local, state and federal regulations. Notify the Owner's Project Representative at least two (2) weeks prior to scheduled date of application.

1.07 QUALITY ASSURANCE

- A. Subcontract planting work to a single landscape construction company specializing in this work. All work shall be performed by experienced landscape professionals familiar with planting procedures and under the full-time supervision of a qualified foreman. The General Contractor shall notify the Architect in writing upon the selection of a landscape subcontractor and arrange for a pre-construction meeting between the Architect, General Contractor, and Subcontractor. Such meeting shall seek to establish the proposed schedule, source of plants, consideration of substitutions and general review of procedures.
- B. Inspection of Plant Materials: Plant materials are subject to inspection and approval upon delivery to the project site. Certificates of inspection of plant material shall be furnished as may be required by Federal, State and other authorities. No plants shall be planted until required inspections have been made and the plants approved.
- C. Label at least one tree and one shrub of each species within each plant grouping with a securely attached waterproof tag bearing legible designation of botanical and common name.

1.08 PLANTING SEASONS

- A. Complete landscaping work as quickly as possible as portions of the site become available for this work. Work only within seasonal limitations for proper planting as follows:

Type of Plant Material	Spring Season	Fall Season
Evergreen Trees & Shrubs	April 15 to June 1	Aug. 15 to Oct. 1
Deciduous Trees & Shrubs	Shall be planted in a dormant condition.	

- B. Planting performed outside of these seasonal limitations will not be accepted unless approval is obtained in writing from the Architect. Any approved work outside of these seasonal limitations pertains only to the work to be performed in the season of the year requested.

1.09 DELIVERY, STORAGE AND HANDLING

- A. Packaged Materials: Deliver packaged materials in manufacturer's original unopened containers showing weight, analysis and name of manufacturer. Comply with manufacturer's instructions and recommendations for storage and handling. Protect all materials from damage, deterioration, injury and theft while stored at the site.

1.10 EXAMINATION OF CONDITIONS

- A. All areas to be planted shall be inspected by the Contractor prior to starting work and any incorrect grading or inadequate drainage shall be reported to the Architect prior to beginning work.

PART 2 - PRODUCTS

2.01 LOAM

- A. Loam for planting shall be approved, specified, provided, and installed under the work of Section 32 91 00, Loam and Planting Preparation, and that has been pH adjusted according to particular planting applications and improved through the addition of organic material as directed under this Section.
- B. Planting loam mix for groundcover, perennial and bulb planting shall have a pH value of 5.5 to 6.5, which has been thoroughly premixed with organic material in the proportions of one part organic matter (humus or compost), with 5 parts of approved loam. Organic material shall be specified, provided, and installed under Section 32 91 00, Loam and Planting Preparation.

2.02 SOIL ADDITIVES

- A. Soil additives shall be specified, provided, and installed under the work of Section 32 91 00 Loam and Planting Preparation.
- B. For trees/shrubs planted late in the season after October 1st (or any transplant) Use Granular Mycorrhizal inoculant product for plant establishment per manufacturer recommendation. Mycor Tree Saver Transplant as manufactured by Plant Health Care Inc, Pittsburgh PA, or approved equal as determined by Landscape Architect.
- C. NutriPak slow-release tree and shrub fertilizer in two strengths – 1-2 years (fruit trees) and 3-5 years (hardwood). Apply as directed by the manufacturer.

2.03 STANDARD OF PLANTS

- A. The Contractor shall furnish all plants shown on the Contract Documents. No substitutions will be permitted, without written approval by the Landscape Architect. Furnish plants which have been nursery grown in accordance with the American Standard for Nursery Stock of the American Nursery and Landscape Association (ANLA) and ANSI Z60.1 - latest edition, and which have been grown under climate conditions similar to those in the locality of the project. All plants shall conform to the varieties, sizes and quantities specified on the plans and typical of their species. They shall be free from insects, insect eggs, scale and/or disease. The root system of each shall be well

provided with fibrous roots. Plants shall have a sound, healthy, well-formed upper growth with straight trunks, well-branched and densely foliated when in leaf. Plants shall be legibly tagged with its proper name for purposes of identification of plant material during planting.

1. Measurements: Height and spread dimensions specified refer to the main body of the plant and not from branch or root tip to tip. Measure the caliper of trees up to 4 inches at 6 inches above the ground level at trunk flare. Measure trees larger than 4 inches 1 foot above ground level.
2. Plants larger than specified in the plant list may be used if approved by the Architect, but use of such plants shall not increase the contract price. If the use of larger plants is approved, the spread of roots or ball of earth shall be increased in proportion to the size of the plant.

2.04 BARK MULCH

- A. Bark Mulch: for planting beds shall be a pine bark product free from lumps, dirt, deleterious materials, or color additives. Bark shall be substantially free from wood fibers. No pieces of bark shall exceed three (3) inches in any dimension, or be thicker than 1/4 inch. Mulch shall have been aged for a minimum of six months, and not longer than two years. Bark shall be no more than two years old. All plant beds shall receive a two to four inch layer of mulch, not to exceed four inches.

2.05 WATER

- A. Water: shall be furnished by the Contractor from a legal off-site source via water truck and be suitable for irrigation, free of toxic ingredients. Sources of water at or near the site that are made available to the Contractor are a convenience to the Contractor. Limitations of site water sources shall be supplemented by off-site sources at the Contractor's expense to meet the maintenance requirements of this Section. Any municipal fees associated with providing water for this work shall be borne by the Contractor.
 1. Watering Equipment: The Contractor shall furnish sufficient watering equipment to distribute water evenly with complete coverage daily to all seeded areas.
 2. All new and transplanted trees shall be furnished and installed with 20 gallon, slow release watering Treegator bags or approved equal. Manufactured by Spectrum Products, Inc., Youngsville, NC, phone 1-800-treegator.

2.06 ANTIDESICCANTS

- A. Antidesiccants shall be emulsions or other materials which will provide a protective film over plant surfaces permeable enough to permit transpiration and specifically manufactured for that purpose. Antidesiccant shall be "Wilt-Pruf" available from Nursery Specialty Products, Inc., New York, N.Y. or approved equal, and mixed and applied according to the manufacturer's instructions.

2.07 TREE ANCHORING MATERIALS

- A. Stakes: For supporting small trees under 3" caliper shall be of sound wood uniform in size, reasonably free of knots, and capable of standing in the ground at least two years. Stakes shall be 2"x 2," not less than eight and one half feet in length and stained with non-toxic dark brown stain. All trees 3" caliper or over shall be supported by guying cable

as per planting detail.

- B. Arbor Ties: Utilize Arbortie by Deeproot, or approved equal, when staking and guying plant material.

2.08 TREE WRAPPING MATERIALS

- A. Wrapping Material: shall only be as directed by the Landscape Architect. Product to have a lifetime warranty, crinkled to 33-1/3% stretch. It shall consist of two layers of craft with asphalt based material between them, similar to and equal to the "Leonard Crinkled Paper Tree Wrap", as manufactured by the A.M. Leonard, Piqua, OH or approved equal.

2.09 PLUGS

- A. Plugs shall be in 2 3/8" square X 3 3/4" deep open-bottomed pots. Plugs shall be thoroughly rooted through the container. No species shall be substituted without approval of the architect.

PART 3 - EXECUTION

3.01 PLANTING

- A. All plant roots and earth balls must be kept damp and thoroughly protected from sun and drying winds at all times from the beginning of the digging operation, during transportation, and on the ground until the final operation of planting.
- B. Prior to spreading loam, subgrades shall have been tested to determine if they are too compact to drain water as specified.
- C. Plant material Selection: at least one month prior to the expected planting date, the Contractor shall request that the Landscape Architect select and tag plants to be planted as specified. The Contractor shall pay for the transportation, subsistence and overnight accommodations, if necessary, for the Landscape Architect's representative during the period of time required to select and tag the plant material.
 - 1. The Contractor shall be responsible to certify the availability of quality plants in specified sizes from his/her sources of supply prior to requesting that the Landscape Architect make plant source inspections. In the event that plants at the inspection location are found to be unavailable or of insufficient size, the Contractor shall be liable to reimburse the Owner for all costs of the Landscape Architect's hourly services which are incurred during unproductive inspection trips.
 - 2. Unless specifically designated otherwise, a representative of the Contractor shall accompany the Landscape Architect on all plant material selection field trips.
 - 3. Representative samples only of shrubs, perennials and groundcover plants may be tagged or marked for approval as an "Approved Typical Sample" and shipped to the site. Any shrub or groundcover plant that arrives at the construction site that does not meet the Approved Typical Sample will be rejected by the Landscape Architect.
 - 4. Inspection and approval of plants at the source shall not impair the right of subsequent inspection and rejection upon delivery to the site, or during the progress of the work if the Landscape Architect finds that plants do not meet the

requirements of the PLANT LIST or this Contract, have declined noticeably due to handling abuse, lack of maintenance, or other causes. Cost of replacements, shall be borne by the Contractor.

- D. Contractor shall locate all existing underground utilities of the proposed planting and notify the Architect of any conflicts prior to digging.
- E. Locations for all plants shall be staked-out on the ground and approved by the Architect before any excavation is made. Adjustments in locations shall be made as directed by the Architect. Planting shall be in accordance with the planting details on the Drawings.
- F. The Contractor shall take special care to ensure that the plant material is not planted too deeply by removing burlap and soil mounded around the base of the plant, at the top of the rootball, to expose the trunk flare. A measurement shall be taken from the trunk flare to the bottom of the root ball. This measurement shall be the depth of the planting hole.
- G. The plants shall be set at the center of the holes with trunk flare level to, or 1" – 2" above, finish grade. Once plant is set in planting pit, the Contractor shall remove the top 12" minimum, of wire basket and all visible rope and burlap.
- H. Hole shall be backfilled in layers of loam not more than nine inches and each layer watered sufficiently to settle before the next layer is put into place. Do not place any subsoil, sod or waste materials in planting hole.
- I. Each tree and shrub shall be pruned in accordance with National Arborist Association Standards to preserve the natural character of the plant. Remove all tags, labels and dead or broken branches.
- J. Staking of newly planted trees shall be performed directly after they are planted. Trees of 3-inch caliper or under, require staking only as needed to hold the tree plumb. All trees of 3-inch caliper and over shall be staked. Support ties shall allow tree to move and sway, but be able to return the trunk to a plumb and true position. Contractor shall adjust staking as frequently as needed during the maintenance period.
- K. A 2 – 4 inch settled layer of bark mulch shall be applied over the entire area of the plant beds. Plantings installed over three months prior to the date of substantial completion shall be weeded and replenished with fresh mulch to specified thickness prior to acceptance.
- L. Provide a soil saucer equal to the diameter of the hole around each tree. Particular attention shall be made to create saucers at sloped areas that contain water around the base of the plant. Soil saucers shall be repaired and maintained as needed to perform effectively during the maintenance period.
- M. Plants shall be watered at a rate of 3–5 gallons per inch of caliper twice within the first twenty-four (24) hours of the time of planting.
- N. Plug installation:
 - 1. Use an auger or other appropriate tool to excavate planting holes in a staggered pattern at specified spacing
 - 2. Evenly distribute plugs in informal drifts of 3-7 of any one species with the edges blended into adjacent species to avoid a formal appearance.
 - 3. Plant plugs level with existing soil grade. Be certain that soil is placed around the plugs and firmed into place. Do not fill around plugs with mulch.
 - 4. Thoroughly soak plugged area with water until soil is moist to a depth of 4 inches.

3.02 MAINTENANCE

A. Trees, Shrubs, Perennials, and Groundcover Plantings:

1. The Contractor shall maintain plantings until the date of substantial completion or until the date of acceptance, whichever is later.
2. Maintenance shall begin immediately after each plant is planted and shall include watering, weeding, pruning, pest control, removal of dead materials and otherwise maintaining plants. Correct defective work as soon as possible after it becomes apparent and weather and season permit. Reset settled plants to proper grade and position, restore planting saucer, and remove dead material. Repair soil saucers around trees and replenish bark mulch to meet the specified thickness as needed throughout the maintenance period.
3. Watering: The Contractor shall include in his base bid costs for weekly watering of all plant areas for the entire first growing season. The required watering frequency will vary depending on temperature and natural rainfall. The Contractor shall respond to adverse weather conditions in a timely manner to maintain the moisture level in the soil necessary for proper plant establishment. Plants shall be watered at a rate of 3-5 gallons per inch of caliper. Slow release watering bags shall be filled weekly during this period. Plants subjected to drought stress during the required maintenance period may become unacceptable as determined by the Architect and require replacement at no additional cost to the Owner.
4. Anti-desiccant: Treat plants subject to desiccation at the time of planting and again prior to winter according to the manufacturer's recommendations.
5. During the maintenance period, any damage or decline in the condition of plantings shall require the Contractor to take immediate action to identify potential problems and undertake corrective measures. If required, the Contractor shall engage professional arborists and/or horticulturalists to inspect plant materials and to identify problems and recommend corrective procedures. The Landscape Architect shall be immediately advised of such actions. Inspection and recommendation reports shall be submitted to the Architect.

3.03 ACCEPTANCE

- A. Upon completion of planting work per Construction Phase, the Contractor shall request in writing that the Landscape Architect formally inspect the planting work. The General Contractor, Owner, and landscape Architect shall walk all areas of completion to determine date of turnover to the Owner.
- B. Following the correction of all Punch List deficiencies, the Contractor shall request in writing that the Landscape Architect formally inspect the planting work. If plant materials and workmanship are acceptable, the Landscape Architect will issue a written Certificate of Final Acceptance to the Contractor.

3.04 PLANT GUARANTEE

- A. The date of the Certificate of Final Acceptance shall establish the commencement of the required one-year guarantee and establishment period for planting work.

- B. At the end of the guarantee and establishment period, a final inspection will be held to determine whether any plant material replacements are required. Plants found to be unacceptable shall be removed promptly from the site and replaced.
- C. All replacements shall be plants of the same kind and size originally specified. The cost shall be borne by the Contractor, except for possible replacements due to vandalism or neglect on the part of others.

3.05 CLEANING AND PROTECTION

- A. During operations, keep pavements clean and work area in an orderly condition. Protect all plantings from damage by other contractors and trades and trespassers. After completion of the work, the Contractor shall remove all debris, materials, rubbish, excess dirt, etc. from the site and dispose of them in a legal manner. The premises shall be left clean and presentable to the satisfaction of the Architect.

END OF SECTION

SECTION 32 91 00
LOAM AND PLANTING PREPARATION

PART 1 - GENERAL

1.05 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 apply to the work of this Section.

1.06 DESCRIPTION OF WORK

- A. The work of this Section consists of providing all labor, equipment, materials, incidental work, and construction methods necessary to perform all lawns, plantings and related work as indicated on the Contract Documents and as specified in this Section and includes, but is not limited to, the following:

1. Subgrade preparations
2. Stripping existing topsoil and planting soil material acquisition
3. Testing and analysis for specification conformance
4. Preparation of mixes and testing for conformance
5. Mockup
6. Installation and placement of soils
7. Fine grading
8. De-compaction and re-compaction of soils
9. Final in-place testing of soils
 - 1) Coordination with other contractors
 - 2) Inspection and acceptance
10. Cleaning and protection

B. Sustainable Building Requirements:

1. The Contractor is to implement practices and procedures to meet the project's sustainable performance goals, which include achieving LEED v4 Silver certification based on USGBC's "LEED Version 4 for Building Design and Construction: Schools" (LEED v4 BD+C: Schools).
2. The work of this Section includes responding to Architect or Contractor requests for additional information or product data and may be required following initial Green Building Certification Institute (GBCI) review of LEED Application.
3. Product substitution requests are subject to additional LEED submittal requirements including, but not limited to, Environmental Product Declarations (EPD), Health Product Declarations (HPD), and General Emissions Testing.

1.07 REFERENCES

- A. Comply with applicable requirements of:

1. State of Massachusetts, Standard Specifications for Highways and Bridges, Department of Public Works, latest edition.

2. American Association of Nurserymen, American Standards for Nursery Stock, (ANSI Z60.1), latest edition, published by the American Association of Nurserymen, 1250 I Street, N.W., Suite 500 Washington, D.C. 20005.
- B. American Society for Testing and Materials (ASTM):
1. D 75 Practice for Sampling Aggregates
 2. D 422 Test Method for Particle-Size Analysis of Soils
 3. D698-00a Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³)
 4. D1557 Moisture-Density Relations of Soils and Soil-Aggregate Mixtures using 10-lb rammer and 18-in. drop
- C. A.O.A.C.: Association of Official Agricultural Chemists.

1.08 RELATED WORK

- A. Carefully examine the site and all of the Contract Documents for requirements that affect the work of this Section. No claim for additional costs will be allowed because of lack of full knowledge of existing conditions. Other specifications sections that directly relate to the work of this Section include, but are not limited to, the following:
1. Section 024113 - Site Preparation
 2. Section 311000 – Site Clearing
 3. Section 312500 – Erosion and Sedimentation Controls
 4. Section 312000 – Earth Moving
 5. Section 323000 - Site Improvements
 6. Section 328400 - Irrigation
 7. Section 329000 – Planting
 8. Section 329200 - Turf and Grasses
 9. Section 334000 – Storm Drainage Utilities
- B. The work of this Section shall be coordinated with that of other trades affecting, or affected by, this work, as necessary to assure the steady progress of all work of the Contract.

1.09 TESTING, SUBMITTALS, MOCK-UPS AND INSPECTIONS

- A. At least 30 days prior to ordering materials, the Contractor shall submit to the Architect representative samples, certifications, manufacturer's product data and certified test results for materials as specified below. No materials shall be ordered or delivered until the required submittals have been reviewed and approved by the Architect. Delivered materials shall closely match the approved samples. Approval shall not constitute final acceptance. The Architect reserves the right to reject, on or after delivery, any material that does not meet these Specifications.
- B. Samples: Prior to ordering the below listed materials, submit representative samples to the Landscape Architect and Soil Scientist, Owner's Representative for selection and approval. Do not order materials until Landscape Architect, Owner's Representative's and Soil Scientist's approval has been obtained. Delivered materials shall closely match the approved samples.
1. Organic amendment (Compost): duplicate samples of 1 gallon.
 2. Stripped Existing Topsoil: duplicate samples of 1 gallon.

3. Coarse Sand: duplicate samples of 1 gallon.
 4. Athletic Field Soil after approval of individual components: duplicate samples of 1 gallon.
 5. Sod Farm Growing Media: 1' by 1' section of sod to be used on the project, if sod is to be used.
- C. Sources for Soil Components and Soil Mixes: Submit information identifying sources for all soil components and the firm responsible for mixing of soil mixes.
1. Landscape Architect, Soil Scientist and Owner's Representative shall have the right to reject any soil provider. Soil components must be approved in writing prior to delivery to site.
 2. Recommended vendors for soil components.
 - 1) Read Custom Soils, 5 Pond Park Road, Suite L, Hingham Massachusetts, 02042 781-828-6300, sales@readcustomsoils.com Contact: Mark Pendergast
 - 2) D & H Loam, 2352 Main Street, Concord, Massachusetts, 978-897-4901, sales@dhloam.com Contact: Tom Dexter
 - 3) New England Specialty Soils (N.E.S.S.), 435 Lancaster Street, Leominster, Mass, 978-230-2300, Bob@nesoils.com ,Contact: Bob Doran
 - 4) AgreSource inc., 110 Boxford Road, Rowley, MA 01969, 978.388.5110, info@agresourceinc.com. Contact: Dave Harding
- D. Testing for Athletic Field Soil (Sod – Bid Alt): Testing is required at the following intervals:
1. Testing of individual components for all soil mixes. Tests are as described in this Section.
 2. After test results for components have been accepted, create pilot batch mixes of Athletic Field Soil mix and perform tests described in this Section.
 3. After the test results for Athletic Field Soil mix has been accepted, and during the manufacture and placement of Athletic Field Soil, test every 500 cubic yards of soil mix prior to placement on the field areas.
 4. Prior to submitting sod for approval, submit sample of Sod Farm Growing Media and test analysis.
- E. Existing On-Site loam: Sample and test existing on-site loam. The Contractor shall sample the existing loam soils of the construction site in the following manner:
1. The Contractor shall provide a one cubic foot representative sample per each 1,000 cubic yard on-site stockpile of existing loam for testing. All stockpile sampling shall be per ASTM D 75 and Appendixes for securing samples from stockpiles.
 2. Preparation of Samples: Contractor shall place these soil slices into a large, clean plastic container and mix thoroughly. Contractor shall take one cup of soil mixture and dry it at room temperature (do not dry samples in an oven or on a stove or radiator). Once the soil is dry, place the soil in sandwich size zip-type plastic bag and close it tightly. Label each sample on outside of bag, identifying sample by soil type and acre. Provide an approved site plan showing locations of stockpiles cross referenced to soil samples and test results.
- F. Loam from off-site, if on-site loam is insufficient: The Contractor shall provide a one cubic foot representative sample per each 1,000 cubic yard proposed stockpile of loam borrow for testing. All stockpile sampling shall be per ASTM D 75 and Appendixes for securing samples from stockpiles.
- G. Testing shall be at the Contractor's expense. Contractor shall deliver all samples to testing laboratories via overnight courier and shall have the testing report sent directly to the Architect. Perform all tests for gradation, organic content, soil chemistry, soil CEC and pH by UMASS Soil and Plant Tissue Laboratory, West Experiment Station, 203 Paige Laboratory, 161 Holdsworth Way, Amherst, MA 01003, (413) 545-2311. Testing reports shall include the following tests and

recommendations.

1. Mechanical gradation (sieve analysis) shall be performed and compared to the USDA Soil Classification System. Percent clay (0.002 mm) shall be reported separately in addition to silt (ASTM D-422-63, hydrometer method). The silt and clay content shall be determined by a Hydrometer Test of soil passing the #270 sieve.
2. Percent of organics shall be determined by the loss on ignition of oven-dried samples. Test samples minus #10 material shall be oven-dried to a constant weight at a temperature of 450 degrees Fahrenheit (752 degrees Centigrade).
3. Chemical analysis shall be undertaken for Nitrate Nitrogen, Ammonium Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, extractable Aluminum, Lead, Zinc, Cadmium, Copper, Soluble Salts, and pH and buffer pH. A Conductivity Meter shall be used to measure Soluble Salts in 1:2 soil/water (v/v). Except where otherwise noted, nutrient tests shall be for available nutrients.
4. Soil analysis tests shall show recommendations for soil additives to correct soils deficiencies as necessary, and for additives necessary to accomplish lawn and planting work as specified.

H. In-Place Testing

1. Density Tests: ASTM D1556 Density of soil and rock in place using "Sand Cone Method" or ASTM D6938-08a Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth). ASTM D698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. (Standard Proctor).
 - 1) In-place density tests shall be carried out at a rate of one test per each plant bed or lawn area.
 - 2) Soil density shall meet the requirements specified herein, see PART 3.
2. As required, in-place infiltration tests shall be performed using Turf-Tec IN2-W Infiltrometer utilizing manufacturer's operating instructions or accepted alternate.
3. At the direction of the Landscape Architect in-place planting soil blends shall be sampled and tested by the Owner for compliance with gradation and organic matter content as specified herein. Non-compliant materials shall be removed from the site or amended as specified.

I. Compost: Submit supplier's certification of contents being supplied conforms to these Specifications.

J. Limestone: Submit supplier's certification that the limestone being supplied conforms to these Specifications.

K. Acidulant: Submit supplier's certification that the acidulant being supplied conforms to these Specifications.

L. Fertilizer:

1. Submit product data of seeding/sodding fertilizer and certificates showing composition and analysis. Submit fertilization rates for fertilizer product based upon soil testing, analysis, and recommendations as specified, performed, and paid for under in this Section.

M. Gypsum: Submit manufacturer's product data.

N. Mockup and Inspection

1. The Contractor shall not place Athletic Field Soil prior to inspection and approval of Landscape Architect and Soil Scientist for compliance with this Section. The Contractor shall request inspection before proceeding at least ten working days prior to placement of soils.
2. The Contractor shall not place sod prior to inspection and approval of Landscape Architect and Soil Scientist for compliance with soil depth and compaction specifications. The Contractor shall request inspection before proceeding at least ten working days prior to placement of sod.

1.10 REGULATORY REQUIREMENTS

- A. Strictly comply with all applicable codes, regulations and requirements having jurisdiction.
- B. All fertilizer applications shall be performed by a licensed applicator in strict conformance with all local, state and federal regulations. Notify the Owner's Project Representative at least two (2) weeks prior to scheduled date of application.

1.11 EXAMINATION OF CONDITIONS

- A. The Contractor and any sub-Contractor responsible for the execution of the Work of this Section, shall review the subgrades and elevations to verify that the subgrades have been prepared as required by the Contract Documents, prior to proceeding with the spreading of the planting loam. Carefully review the requirements of this Section, to understand the requirements of percolation testing, compaction, slope and absence of debris of the subgrade prior to spreading of the loam borrow.
- B. The Contractor shall be solely responsible for judging the full extent of work requirements involved, including but not limited to sampling and testing of all materials prior to final planting installation.

1.12 DEFINITIONS/QUALITY ASSURANCE

- A. The following definitions shall apply to the work of this Section.
 - 1. The following size distributions of mineral particles by diameter and sieve size shall apply to the following conventional names of soil types:

<u>Conventional Name</u>	<u>Retained on U.S. Sieve No.</u>	<u>Diameter (mm)</u>
Very coarse sand	#18	1 - 2
Coarse sand	#35	0.5 - 1
Medium sand #	60	0.25 - 0.5
Fine sand	#140	0.10 - 0.25
Very fine sand	#270	0.05 - 0.10
Silt	by hydrometer	0.002 - 0.05
Clay	by hydrometer	Less than 0.002

- 2. Subgrade: Soil material and levels resulting from the approved rough grading work.
- 3. Existing Topsoil: In place soil at lawn and planted areas that will be stripped, screened and amended and re-used as a component of manufactured soil blends.
- 4. Imported Base Loam: Base Loam obtained by an approved soil supplier for off-site manufacture of soil blends to be imported to the project site.
- 5. Lawn and Planting Soils: Lawn and Planting Soils are composed of a blend of three base components: base loam or stripped topsoil, organic material and sand. The quality of the blend depends on the quality of the original components. Locate and obtain approval of sources for base loam, organic material and sand that meet the Specification requirements. Contractor is then responsible for mixing the components. Approximate mixing ratios are provided, but may require adjustment, depending on the final materials and with the approval of the Architect or their representative, in order to meet Specification requirements for each blend.
- 6. Athletic Field Soil: Athletic Field soil is composed of a blend of three base components: Stripped existing topsoil, organic material and sand. The quality of the blend depends on the quality of the original components. Contractor responsible for stripping topsoil without admixture of

subsoils, as well as locating and obtaining approval of organic material and sand that meet the Specification requirements. Contractor is then responsible for mixing the components at an off-field location. Approximate mixing ratios are provided, but may require adjustment, depending on the final materials and with the approval of the Architect or their representative, to meet Specification requirements for each blend.

- 1) Base Components
 - a) Stripped Existing Topsoil: The upper 6-12 inches of topsoil stripped from the project site and exported off site to an area designated for soil blending. Contractor is responsible for ensuring neither B-horizon subsoils nor subgrade is stripped with the topsoil.
 - b) Imported Base Loam (if needed): a natural A-Horizon growing medium.
 - c) Organic Material or Compost: a fully decomposed organic material.
 - d) Sand: uniformly graded medium to coarse sand. Washed concrete sand often meets Specification Requirements.
- 2) Athletic Field Soil Mix
 - a) Athletic Field Soil: a soil blend of the above components for Athletic Field planting.
- B. Contractor is solely responsible for quality control of the Work.
- C. The installer shall be a firm having at least 5 years of successful experience of a scope similar to that required for the Work, including the preparation, mixing and installation of custom Planting Soil and planting mixes in urban locations.
 1. The installing contractor shall be the same firm that is installing planting as described in Section 329000 – PLANTING.
 2. Installer Field Supervision: Installer to maintain an experienced full-time supervisor on Project site when any Planting Soil preparation work is in progress.
 3. The installer's crew shall be experienced in the installation of soil, grading and interpretation of grading plans in urban areas.
- D. Soil work shall be performed by a firm that has sufficient earthwork machinery at the job site simultaneously to amply provide for the vigorous execution of the site work without interruption or delay, except for unforeseen circumstances, such as weather. Machinery operators shall be well experienced in this type of work.
- E. Fine grading for athletic field loam and infields shall be performed with dual-plane laser-controlled mini-grader meeting the low ground pressure requirements specified herein and capable of grading to +/- 1/8". Rear mounted box grading equipment is not permitted.
- F. Comply with applicable requirements of the laws, codes, ordinances and regulations of Federal, State and municipal authorities having jurisdiction. Obtain necessary approvals from all such authorities.
- G. Comply with all requirements for control of silt and sediment during soil installation work as indicated in the contract documents. Provide additional silt and sediment control to maintain silt and sediments within the working area as required by the progress of the work or as directed by the Landscape Architect
- H. Pre-installation Conference: Conduct conference at project site prior to the start of any work related to Planting Soil preparation and shall meet the requirements of this Section.
- I. Layout and Grading:
 1. Permanent benchmarks shall be established by a registered land surveyor or professional civil engineer, at the Contractor's expense. The Contractor shall maintain established bounds and benchmarks and replace them, if any are destroyed or disturbed.

2. The Contractor shall maintain at the site, sufficient surveying equipment to accurately excavate to the required subgrade and install soil to the required finish grade. The Contractor shall be responsible to install soil profiles at the elevations and thickness shown on the Plans.

1.13 DELIVERY, STORAGE AND HANDING

- A. Material shall not be handled or hauled, placed or compacted when it is wet as after a heavy rainfall, early spring or if frozen. Soil shall be handled only when the moisture content is compliant with this Specification. Protection of stockpiles during the winter and spring months is essential. The Landscape Architect, Soil Scientist and the Owner shall be consulted to determine if the soil is too wet to handle.
- B. Store and handle packaged materials in strict compliance with manufacturer's instructions and recommendations. Protect all materials from weather, damage, injury and theft.
- C. Sequence deliveries to avoid delay. On-site storage space is permissible only with written notice from the Owner. Deliver materials only after preparations for placement of soil have been completed.
- D. Prohibit vehicular and pedestrian traffic on or around stockpiled soil.
- E. Soil that is to be stockpiled longer than two weeks, whether on or off site, shall not be placed in mounds greater than ten feet high. Windrows are the preferred manner of stockpiling.
- F. Vehicular access to the site is restricted. Before construction, the Contractor shall submit for approval a plan showing proposed routing for deliveries and site access.
- G. Soil Moisture Content
 1. Contractor shall not move, blend or grade soil when moisture content is so great that free moisture is apparent, nor when it is so dry that dust will form in the air or that clods will not break readily, nor when it is frozen. Apply water, if necessary, or allow to dry to bring soil moisture between 60% of optimum moisture content and optimum moisture content as determined by ASTM D698 for compaction, grading and plantings.
 2. Field Soil Moisture Test procedure is applicable for general soil moving and placement only and is not a replacement for the above testing procedure.
 - 1) Form soil in palm of hand, if soil retains shape and crumbles upon touching, the soil may be worked.
 - 2) If the soil will not retain shape, it is too dry and should not be worked.
 - 3) If the soil retains shape and will not crumble, it is too wet and should not be worked.
 - 4) If the soil glistens or free water is observed when the sample is patted in the palm of hand the soil is too wet and should not be worked.
- H. Topsoil to be re-used shall be stripped without admixture of subsoil and moved to a designated for soil blending. The stripped topsoil shall be uniformly blended with other soil components to meet the requirements of this Specification and delivered back to the project site for placement.
- I. Contractor is responsible for the restoration of the designated soil blending area to pre-construction conditions.

PART 2 - PRODUCTS

2.05 LOAM

- A. Loam: The Contractor shall provide additional loam as necessary to complete the work of this Section from off-site sources if there is not sufficient material on site suitable to complete the Work. The Contractor shall submit samples and an analysis from each proposed source of material. Provide loam that is fertile, friable, natural loam reasonably free from subsoil, clay

lumps, glass, brush, litter, roots, stones and other foreign materials.

- B. Loam shall be one of the following sandy loams; "coarse sandy loam", or "sandy loam" determined by mechanical analysis ASTM D-422 and based on the USDA Classification System, and as defined in this Section. It shall be uniform in composition, without admixture of subsoil. It shall be free of stones greater than one and one-quarter inches, lumps, plants and their roots, debris and other extraneous matter, such as glass, brick, metals, plastics, etc. as determined by the Landscape Architect.

1. **Loam for trees, shrubs, groundcover and vines, and perennials** shall have the following grain size distribution for material passing the #10 (2.0 mm) sieve:

<u>US Sieve No.</u>	<u>Percent Passing by Weight</u>	
	<u>Minimum</u>	<u>Maximum</u>
10	100	
18	85	95
35	60	85
60	42	65
140	21	44
270	18	24
0.02	2	4

- 1) The final mix shall have an organic content between 5 and 7 percent by weight.
 - 2) pH shall be between 5.5 and 6.5.
 - 3) Gravel in the loam mix shall be <10%.
 - 4) The ratio of the particle size for 80% passing (D80) to the particle size for 30% passing (D30) shall be 6 or less (D80/D30 <6)
 - 5) The final mix shall have a hydraulic conductivity of not less than 1.5 inches per hour according to test procedure ASTM D5856-95 (2000) when compacted to a minimum of 86 percent Standard Proctor ASTM D 698. Tests shall be by combined hydrometer and wet sieving in compliance with ASTM D422 after destruction of organic matter by ignition.
2. **Loam for general lawns** shall have the following grain size distribution for material passing the #10 (2.0 mm) sieve:

1)	<i>U.S. Sieve Size No.</i>	Percent Passing	
		<i>Minimum</i>	<i>Maximum</i>
	10	100	100
	18	70	90
	35	45	72
	60	28	44
	140	16	24
	270	12	16
	0.002mm	2	4

- 2) On-site and off-site loam shall be screened to achieve above specified sieve analysis.
- 3) Percent Gravel in the loam mix shall be <20%.
- 4) Organic content shall be between 3.5 and 5.0 percent by weight.
- 5) pH shall be between 6.3 and 6.8
- 6) Saturated hydraulic conductivity of the mix shall not be less than 4.0 inches per hour according to ASTM D5856-95 (2000) when compacted to a minimum of 88% Standard

Proctor, ASTM 698.

3. **Loam for athletic fields** shall have the following characteristics:

1.	Gradation for Material Passing the Number 10 Sieve: Percent Passing		
	U.S. Sieve Size No.	Minimum	Maximum
	10	100	100
	18	70	90
	35	45	72
	60	26	40
	140	14	20
	270	10	13
	0.002mm	2	4

- 1) Maximum size shall be one-inch largest dimension. The maximum retained on the #10 sieve shall be 20% by weight of the total sample.
 - 2) Ratio of the particle size for 70% passing (D70) to the particle size for 20% passing (D20) shall be 4.2 or less ($D70/D20 < 4.2$).
 - 3) Saturated hydraulic conductivity of the mix shall not be less than 4.0 inches per hour according to ASTM D5856-95 (2000) when compacted to a minimum of 88% Standard Proctor, ASTM 698.
 - 4) Organic content shall be between 4.5 and 6.0 percent by weight.
 - 5) pH shall be between 6.2 and 6.8
 - 6) Chemical analysis shall be undertaken for Phosphorus, Potassium, Calcium Magnesium, Aluminum, Iron, Manganese, Lead, Cation Exchange Capacity, Soluble Salts, acidity (pH) and buffer pH.
- C. Organic content: loam shall contain not less than 6% or more than 10% organic (unless specified differently herein) matter of the sample that passes a 1/4" sieve when determined by the wet combustion method on a sample dried at 105 degrees.
1. Loam borrow shall be pH adjusted for particular planting applications and shall be adjusted prior to delivery to the Project sites as recommended by UMASS Soil & Plant Tissue Laboratory test results.
 - 1) When pH of loam borrow is equal to or greater than 7 use aluminum sulfate to adjust pH downward to required levels.
 - 2) When pH of loam borrow is less than 7 use either sulfur or ferrous sulfate to adjust pH downward to required levels.
 - 3) When pH of loam borrow must be raised to the required levels use limestone.
 - 4) Regardless of amendment Contractor chooses to use, Contractor, not the Owner, shall be responsible for obtaining specified pH by seeding and/or planting time.
- D. Loam shall be uncontaminated by salt water, foreign matter and substances harmful to plant growth. Topsoil shall not have levels of extractable aluminum greater than 200 parts per million except for acid-loving plants. Cation Exchange Capacity (CEC) shall be between 10 and 15.

- E. All planting loam provided from off-site sources shall be brought to the site meeting all specification requirements. There must be no mixing or amending of soil on site. The loam borrow must not be handled or moved when in a wet or frozen condition.
- F. Screened loam which has been stockpiled on the site may be used provided it can be made to comply with this Specification and that it has been screened to meet the above requirements.
- G. To assure planting loam purchased and screened loam stockpiled fulfills specified requirements regarding textural analysis, organic matter content, and pH, soil testing results shall be obtained by the Contractor and submitted to the Architect for approval before any soil is delivered to the site.

2.06 SOD FARM GROWING MEDIUM (SOD – BID ALT)

- A. Sod to be placed on the site shall be grown in a sand-based soil meeting the following sod farm growing media requirements and shall have no greater than 1/2-inch of thatch.
- B. Soil in which sod was grown at the Sod Farm shall be USDA classified as sand and shall conform to the following grain size distribution for material passing the #10 sieve:

U.S. Sieve Size Number	Percent Passing	
	Minimum	Maximum
10	100	-
18	85	100
35	60	85
80	25	40
140	6	26
270	4	18
0.002mm	2	5

- C. The maximum particle size shall be 1/2 inch.
- D. The maximum retained on the #10 sieve shall be 10% by weight of the total sample. Tests shall be by combined hydrometer and wet sieving in compliance with ASTM D422.

2.07 SOIL ADDITIVES

- A. Soil additives shall be used to counteract soil deficiencies as recommended by the soils analysis.
- B. Lime: Provide approved agricultural limestone containing not less than 85% of total carbonates with a minimum of 30% magnesium carbonates. Lime shall meet Massachusetts Department of Food and Agriculture standards for Fine-Sized Classification so that 50% passes a 100 mesh, 60% passes through a 60-mesh sieve, and 95% will pass a 20 mesh sieve.
- C. Aluminum Sulfate shall be unadulterated, 57% (Ortho Division, Chevron Chemical Company), or approved equal.
- D. Compost: Provide compost as needed to raise the Organic Content of the topsoil to within specified range. Compost shall be:
 - 1. Compost shall be derived from organic wastes including sawdust, clean ground wood, leaf and yard residues, and biosolids that meet all State Environmental Protection Agency requirements. The product shall be well composted, free of viable weed seeds and contain material of a generally humus nature capable of sustaining growth of vegetation, with no materials toxic to plant growth. The material shall be fully composted and to have maintained a temperature above 55 degrees Centigrade or 131 degrees Fahrenheit for at least 15 days per

EPA/40 CFR Part 503. The composted material shall have a moisture content such that no visible free water or dust is produced when handling the material. Submit complete product analysis including: Organic Nitrogen, Carbon/Nitrogen Ratio, Total Phosphorous, Total Potassium, Organic Matter, pH, particle size and product density.

2. Compost products shall meet the following physical criteria:

<u>Parameters</u>	<u>Range</u>
pH	5.5 – 8.0
Moisture Content	35% - 55%
C:N ratio	15 – 30:1
Organic Matter	> 40%
Particle Size	< 3/4"
Soluble Salts	< 4.0 mmhos (ds)
Bulk Density	< 1200 lbs/cuyd
Foreign Matter	< 1% by weight
Solvita Maturity Rating	5 - 7

3. Acceptance of composted products shall be based on the following submittals by the Contractor:

- 1) A request for Approval of a Material Source.
- 2) A copy of the Composting Permit for the Material Source selected.
- 3) Certification by the supplier that the compost product meets state EPA guidelines and that it originates from 100 percent recycled vegetation material that has been aerobically composted.

E. Medium to Coarse Sand

1. Sand for Planting Soil Blends, protection of filter fabric and for sand drainage layer as required, shall be uniformly graded medium to coarse sand consisting of clean, inert, rounded to sub-angular grains of quartz or other durable rock free from loam or clay, mica, surface coatings and deleterious materials with the following grain size distribution for material passing the #10 sieve: Washed concrete sand typically meets Specification Requirements.

Percent Passing		
U.S. Sieve Size Number	Minimum	Maximum
10	100	--
18	60	80
35	25	45
60	8	20
140	0	8
270	0	3
0.002mm	0	0.5

1. Maximum size shall be one-inch largest dimension. The maximum retained on the #10 sieve shall be 20% by weight of the total sample.
2. The ratio of the particle size for 70% passing (D₇₀) to the particle size for 20% passing (D₂₀) shall be 2.8 or less (D₇₀/D₂₀ <2.8). Tests shall be by combined hydrometer and wet sieving in compliance with ASTM D422.

3. pH shall be less than 7.5

F. Coarse Sand for Athletic Field soil blend

1. Sand for Athletic Field Soil Blend, protection of filter fabric as required, shall be uniformly graded medium to coarse sand consisting of clean, inert, rounded to sub-angular grains of quartz or other durable rock free from loam or clay, mica, surface coatings and deleterious materials with the following grain size distribution for material passing the #10 sieve: (Concrete sand or C33 sand typically meets specification requirements).

U.S. Sieve Size Number	Percent Passing	
	Minimum	Maximum
10	100	--
18	60	80
35	25	45
60	8	20
140	0	8
270	0	3
0.002mm	0	0.5

2. Maximum size shall be one-inch largest dimension. The maximum retained on the #10 sieve shall be 20% by weight of the total sample.
3. The ratio of the particle size for 70% passing (D70) to the particle size for 20% passing (D20) shall be 3.0 or less ($D70/D20 < 3.0$). Tests shall be by combined hydrometer and wet sieving in compliance with ASTM D422.
4. pH shall be less than 7.5.

- G. Humus shall be natural humus. It shall be free from excessive amounts of zinc, low in wood content, free from hard lumps and in a shredded or granular form. According to the methods of testing of the Association of Official Agricultural Chemists, latest edition, the acidity range shall be approximately 5.5 pH to 7.5 pH and the organic matter shall be not less than 85% as determined by loss on ignition. The minimum water absorbing ability shall be 200% by weight on an oven-dry basis.
- H. Bone meal shall be fine ground, steam cooked, packing house bone with a minimum analysis of 23% phosphoric acid and 4% nitrogen.
- I. Fertilizers: Commercial fertilizer shall be a complete fertilizer complying with all State and Federal Fertilizer laws. Fifty-percent of available nitrogen shall be in a slow-release form as is found in certain urea-form products, or natural organic forms, or a combination of both. The salt index of the fertilizer shall not exceed 35. It shall contain the following percentages by weight.

		Lawns
Nitrogen	(N)	10%
Phosphorus	(P)	10%
Potash	(K)	10%

- J. Fertilizer shall be delivered and mixed as specified, in standard size unopened containers, showing weight, analysis in compliance with Massachusetts Department of Food and Agriculture regulations, and name of manufacturer. It shall be stored in a weatherproof storage place, in such a manner that it will be kept dry, and its effectiveness not impaired.
1. Fertilizer for planting shall be formulated for top-dressing, soil surface application to plants. Fertilizer shall be designed and certified by the manufacturer to provide controlled release of fertilizer continuously for not less than 9 months. One hundred percent of the nitrogen content shall be derived from organic materials. Nitrogen source shall be coated to ensure slow

release. Fertilizer percentages of weight of ingredients shall be as recommended by the soil testing and analysis specified, performed, and paid for under this Section, Loam and Planting Preparation.

- K. Gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) shall be agricultural grade, granular form. Gradation shall conform to the following:

<u>Sieve Designation</u>	<u>Percent Passing by Weight</u>
No. 8 (2.36 mm)	100
No. 16 (1.18 mm)	97
No. 30 (0.60 mm)	82
No. 50 (0.30 mm)	46
No. 100 (0.15 mm)	21

- L. Filter Fabric, as required, shall be Mirafi 140N or approved equivalent.

PART 3 - PART 3 - EXECUTION

3.01 PRE-INSTALLATION EXAMINATION AND PREPARATION

- A. Reference Other Sections as necessary.
- B. Coordinate activities with other project contractors so that there is no soil disturbance from traffic or other construction activities subsequent to placement.
- C. Pre-Installation Examination Required: The Contractor shall examine previous work, related work, and conditions under which this work is to be performed and shall notify Landscape Architect and Soil Scientist in writing of all deficiencies and conditions detrimental to the proper completion of this work. Beginning work means Contractor accepts substrates, previous work, and conditions.
- D. Kickoff Meeting: At least 10 working days prior to the start of work, the contractor shall request a landscape construction kickoff meeting with the owners' representative, landscape architect, soil scientist and any other parties involved with landscape construction. The contractor must demonstrate familiarity with this Section, and other relevant sections of the construction documents. The contractor shall articulate the means and methods of soil blending, subgrade preparation, soil placement and other steps outlined in this Specification.
- E. Examination of Subgrade: The subgrade shall be examined by the Contractor prior to the start of soil installation. Any deficiencies shall be noted and related to the Landscape Architect. Deficiencies include, but shall not be limited to the following:
1. Construction debris present within the planting areas.
 2. The subgrade is at incorrect depths for installing the designed soil profile.
 3. Incomplete irrigation.
 4. Incomplete lighting and exterior electrical installation.
 5. Conflict with underground utilities.
 6. Subgrade contaminated with oils, compressible material, silt or clay
- F. Confirm that the subgrade is at the proper elevation and prepared as required. Subgrade elevations shall slope parallel to the finished grade as shown on the drawings.
1. Slope sides of excavations to comply with local codes and ordinances having jurisdiction. Provide protection measures as required for public safety.
 2. All subgrade areas to be filled with Soil shall be free of construction debris, refuse, vegetation, compressible or decay able materials, all stones greater than three inches,

concrete washout or soil crusting films of silt or clay that reduces or stops drainage from the soil into the subsoil; and/or standing water. Such material shall be removed from the site.

3. The subgrade must slope toward the bottom of slopes and subdrains. Subgrade levels shall be adjusted as required to ensure that all planted areas have adequate drainage.
- G. Do not proceed with the installation of soil, until all utility work in the area has been installed.
1. The Contractor shall identify the locations of underground utilities prior to proceeding with soil work and shall protect all utilities from damage.
- H. Athletic Field Soil Preparation: Mix-in amendments as required by tests and as approved by the Landscape Architect and Soil Scientist. All preparation and mixing shall be accomplished when the soil moisture content is compliant with this Section and at a moisture content approved by the Landscape Architect and Soil Scientist.

3.02 MIXING OF ATHLETIC FIELD SOILS

- A. Athletic Field Soil shall be produced off site with equipment that blends together each component in a thorough and uniform manner. This shall be accomplished by alternately stacking soil components in a pile, layer cake style, and then passing soil components through a screener.
- B. Stockpile blended athletic field soil mix in labeled (ie 0-500cy, 500-1,000cy) stockpiles no greater than 500 cubic yards and have each stockpile tested for conformance to Specification. Adjustment of mix ratios or amendment of stockpiled blended soil may be required, based upon QA/QC testing of stockpiles.

3.03 WORKING AROUND UTILITIES

- A. Carefully examine the civil, record, and survey drawings to become familiar with the existing underground conditions before digging.
- B. Known underground and surface utility lines are indicated on the utility drawings – See Civil and Architect's plans. Contact the local Dig Safe organization and give them their required time to respond and mark the property. Determine location of underground utilities and perform work in a manner that will avoid possible damage. Hand-excavate as required. Maintain grade stakes set by others until parties concerned mutually agree upon removal.
- C. Perform work in a manner that will protect utilities from damage. Hand-excavate as required and provide adequate means of support and protection of utilities during soil installation operations. Maintain grade stakes set by others until parties concerned mutually agree upon removal. The Contractor shall repair all utilities damaged by soil operations at the Contractor's expense.

3.04 FILLING AND COMPACTION

- A. Verify that the subgrade preparations have been reviewed and accepted, including removal of all existing vegetation prior to placement of planting soils.
 1. Notify the Landscape Architect of soil placement operations at least seven calendar days prior to the beginning of work.
- B. Perform percolation tests on existing subsoils or placed fill prior to placing and spreading loam for seeding, sodding, and planting. Placed Loam shall be confirmed to infiltrate as noted:
 1. Perform percolation testing of subsoil or placed fills to determine whether or not the subgrade will drain properly. Perform percolation tests as a rate of one (1)

- per 10,000sf or as directed by the Landscape Architect. A minimum of three (3) infiltration tests per plating area shall be conducted on the site.
- a. Dig a hole in the installed subgrade soil that is a minimum of 8 inches in diameter and 8 inches deep.
 - b. Place a 6 inch deep by 6 inch diameter plastic bucket with a minimum of 50 holes in the sides and bottom to allow free flowing of water, in the excavated hole. Fill the 1-inch space between the bucket and hole sidewall and bottom with concrete sand. Fill the bucket with water and let it drain completely. Immediately refill the bucket with water and measure the rate of fall in the water level.
 - c. In the event that the water drains at a rate less than one-inch per hour (1.0" / 60 minutes), till the sub-soil to a depth required to break the over compaction (min of 6").
2. Perform percolation testing of installed Loam to determine whether or not it will drain properly. Perform percolation tests as a rate of one (1) per 10,000sf or as directed by the Landscape Architect. A minimum of three (3) infiltration tests per planting area shall be conducted on the site. Locations of Loam infiltration tests shall not be within 5' from any previous infiltration test conducted on the subgrade.
- a. Dig a hole in the installed subgrade soil that is a minimum of 8 inches in diameter and 8 inches deep.
 - b. Place a 6 inch deep by 6 inch diameter plastic bucket with a minimum of 50 holes in the sides and bottom to allow free flowing of water, in the excavated hole. Fill the 1-inch space between the bucket and hole sidewall and bottom with concrete sand. Fill the bucket with water and let it drain completely. Immediately refill the bucket with water and measure the rate of fall in the water level.
 - c. In the event that the water drains at a rate less than the following, till the soil to a depth required to break the over compaction.
 - i. General Lawn Areas: 2.0" / 60 minutes
 - ii. Planting Beds: 2.0" / 60 minutes
 - iii. Athletic Field Lawn Areas: 6.0" / 60 minutes.
3. In the event that percolation testing indicates that the subsoil, placed fills or ordinary borrow has been over compacted and will not drain, the contractor shall loosen up the top 6" min of the subgrade (up to 24" depending on compaction level of subgrade) to be planted, seeded, or sodded by ripping or other mechanical means. Recompact the borrow by driving a small, tracked bulldozer over the area at low speeds so that the tracks of the bulldozer pass over the affected area and the soil is compacted to a density that will percolate as specified under the work of this Section. Under no circumstances shall wheeled vehicles be driven over subsoil, placed fills or ordinary borrow that have been shown to percolate or subsoil, placed fills or ordinary borrow that has been loosened and shown to percolate.
- C. Subsoil or ordinary borrow shall have been excavated and filled as required by the Contract Documents. Do not damage the work previously installed. Maintain all required angles of repose of materials adjacent to the loam as shown on the Contract Documents. Do not over excavate compacted subgrades of adjacent pavement or structures during loaming operations.
- D. Confirm that the subgrade is at the proper elevation and that no further earthwork is required to bring the subgrade to proper elevations. Subgrade elevations shall slope parallel to the finished grade and or toward any subsurface drain lines as shown on the

Contract Documents. Provide a written report to the Architect that the subgrade has been placed to the required elevations and that the subgrade drains water at the rates specified under the required percolation tests specified, performed and paid for under this Section, Loam and Planting Preparation. Perform no work of placing and spreading loam until elevations have been confirmed and written report has been accepted by the Architect.

- E. Clear the subgrade of all construction debris, trash, rubble and any foreign material. In the event that fuels, oils, concrete washout or other material harmful to plants have been spilled into the subgrade material, excavate the soil sufficiently to remove the harmful material. Such construction debris, trash, rubble and foreign material shall be removed from the site and disposed of in a legal manner. Fill any over excavation with approved fill and compact to the required subgrade compaction levels.
- F. Do not proceed with the installation of loam until all utility work in the area has been installed.
- G. Protect adjacent walls, walks and utilities from damage or staining by the loam. Use 0.5-inch plywood and or plastic sheeting to cover existing concrete, metal and masonry work and other items as directed during the progress of the work. Clean up all trash and any soil or dirt spilled on any paved surface at the end of each working day.

3.05 FINE GRADING

- A. Finish grades associated with the grading of the athletic field areas shall be performed with laser-guided grading equipment to meet the tolerances required by the Drawings and Specifications. Before spreading loam or infield mix material, the Contractor shall furnish and install grade stakes sufficiently spaced to insure correct line and grade of the finished subgrade. The Contractor shall verify elevations and do whatever additional grading is necessary to bring the subgrade layer to a true, smooth slope parallel to the finish grade for all areas to receive loam.
- B. Immediately prior to dumping and spreading loam, the subgrade shall be in a friable condition, as described herein, cleaned of all stones greater than 2 inches and all debris or rubbish. Such material shall be removed from the site, not raked to the edges and buried. Notify the Architect that the subsoil has been cleaned and request his/her attendance on site to review and approve subgrade conditions prior to spreading loam borrow.
- C. Loam borrow delivered to the site shall be protected from erosion at all times. Materials shall be spread immediately. Otherwise, materials that set on site for more than 24 hours shall be covered with tarpaulin or other soil erosion system acceptable to the Architect and surrounded by silt fence.
- D. No loam borrow shall be handled, planted, or seeded in any way if it is in a wet or frozen condition. A moist loam borrow is desirable.
- E. Soil additives shall be spread and thoroughly incorporated into the layer of loam by harrowing or other methods reviewed by the Architect. The following soil additives shall be incorporated:
 - 1. Ground limestone or acidulant as required by soil analysis to achieve the required pH as described in this Section. Spread limestone at the rate required by soil analysis up to a maximum limit of 200 pounds per 1,000 square feet. Should recommendations of soil analysis require greater rates of application than 200 pounds per 1,000 square feet, a surface application of limestone not in excess of 50 pounds per 1,000 square feet shall be made to the established lawn during the season after Final Acceptance. This second application of limestone shall be performed and paid for under the work of Section 32 92 00, Turf and Grasses, at rates

determined under the testing requirements of this Section, Loam and Planting Preparation.

2. Fertilize at the rate recommended by the soil analysis. For lawn areas, this fertilizer application shall be the first in a series of fertilizer applications made under this Contract and shall be applied and incorporated under this Section, Loam and Planting Preparation. A second and third application of fertilizer for turf areas shall be specified, spread and paid for under Section 32 92 00 Turf and Grasses, of this Specification. For planting areas this fertilizer application shall be primary application and the process of application described under Section 32 90 00, Planting of this Specification and specified, provided, performed and paid for under this Section, Loam and Planting Preparation.
 3. Humus, compost, sand or other soil amendments as required by soil analysis.
- F. Loam shall be sampled and tested as specified, performed and paid for under the work of this Section, to verify application and incorporation of limestone, fertilizer and other soil amendments.
- G. After loam and required additives have been spread, carefully prepare the loam by scarifying, harrowing, or tilling the loam to integrate soil additives into the top 8 inches of the loam. Remove all large stiff clods, lumps, brush, roots, stumps, litter and other foreign matter. Remove from unscreened soils all stones over 3/4 inch in diameter from the top 6 inches of the loam bed. Loam shall also be free of smaller stones in excessive quantities as determined by the Architect and as specified herein.
- H. Sufficient grade stakes shall be set for checking the finished grades. Stakes must be set in the bottom of swales and at the top of slopes. Deviation from indicated elevations that are greater than one-tenth of a foot shall not be permitted. Connect contours and spot elevations with an even slope. Finish grades shall be smooth and continuous with no abrupt changes at the top or bottom of slopes.
- I. Fine grading for athletic field loam and infields shall be performed with dual-plane laser-controlled mini-grader meeting the low ground pressure requirements specified herein and capable of grading to +/- 1/8", fine grade the placed topsoil at athletic fields to a tolerance of 1-inch in 25-feet. The maximum deviation from design grade shall be .75-inch +/- at a maximum tolerance of 1.5-inches in 50-feet. Rear mounted box grading equipment is not permitted.
- J. During the compaction process, all depressions caused by settlement or rolling shall be filled with additional loam and the surface shall be regraded and rolled until presenting a smooth and even finish corresponding to the required grades.
- K. The Contractor shall install loam in successive horizontal lifts no thicker than 6 inches in turf areas and 12 inches in plant bed areas to the desired compaction as described herein. The Contractor shall install the soil at a higher level to anticipate any reduction of loam borrow volume due to compaction, settling, erosion, decomposition, and other similar processes during the warranty period. The Architect will ensure that the full depths of loam for lawn and plant beds are obtained by digging holes in the loam at the same frequency as for compaction testing.
1. Compact loam to the required density as specified.
 2. Maximum dry density for loam shall be determined in accordance with ASTM D698. The following percentages of minimum to maximum dry densities shall be achieved for fill materials or prepared subgrades.

In lawn, plant beds and tree pits:

	Minimum	Maximum
Planting areas in top eighteen inches of finished grade	82%	85%
Lawn Areas in top eight inches of finished grade	84%	86%

3. The surface area of each lift shall be scarified by raking prior to placing the next lift. Soils shall not be compacted with vibratory equipment.
 - L. In addition to the range cited above, compact each lift sufficiently to reduce settling but not enough to prevent the movement of water and feeder roots through the soil. The loam borrow in each lift should feel firm to the foot in all areas and make only slight heel prints. At completion of the loam borrow installation, the soil should offer a firm, even resistance when a soil sampling tube is inserted from lift to lift. After the placement of each lift, perform percolation tests to determine if the soil has been over compacted. Perform the percolation test procedure as described above in Part-3.1:
 1. Holes in 6-inch lift in turf areas shall be 4 inches deep. Holes in 12-inch lifts in plant beds shall be 8 inches deep. Do not penetrate through the lift being tested.
 2. Measure the rate of fall in the water level as described in Part-3.1.
 3. In the event that the water drains at a rate less than two inch per hour, till the soil to a depth required to break the over compaction.
 4. Perform a minimum of one soil percolation test per 10,000 square feet area of turf area and 2,500 square feet of tree and shrub planting area or as directed by the Architect.
 5. Water used in this work shall be furnished by the Contractor and will be suitable for irrigation and free from ingredients harmful to plant life. Hose and other watering equipment required for the work shall be furnished by the Contractor.
 - M. Select equipment and otherwise phase the installation of the loam to ensure that wheeled equipment does not travel over subsoil, placed fills or ordinary borrow or already installed soil. Movement of tracked equipment over said soils will be reviewed and considered for approval by the Architect. If it is determined by the Architect that wheeled equipment must travel over already installed soil, provide a written description of sequencing of work that ensures that compacted soil is loosened and uncompacted as the work progresses or place one-inch thick steel plate ballast (or equivalent ballast approved by the Architect) over the length and width of any travel way to cover loam borrow to protect it from compaction.
 - N. Disturbed areas outside the limit of lawn work shall be graded smooth and spread with a minimum of 6 inches of loam to the finished grade.
 - O. Contractor shall be responsible for maintaining all stockpiles of existing, on-site loam on the site until final placement of all loam has been approved by the Architect in writing. No loam shall be removed from the site unless approved by the Architect in writing. Upon written approval by the Architect, Contractor shall remove all excess, unused existing on-site loam from the site and dispose of it in a legal manner.
 - P. The contractor shall install erosion control matting where required on the drawings and specified under Section 32 92 00 – Turf and Grasses.
- 3.06 SOILS AT PERIPHERY LAWN AND UNDISTURBED SOIL AREAS
- A. Periphery Lawn and undisturbed soil areas and other areas depicted on the plans, shall remain protected for the duration of the Work. Any areas that become disturbed shall be returned to pre-construction conditions at no additional cost to the Owner.
 - B. As required, stripped and stockpiled topsoil shall be used as fill and to augment existing topsoil within periphery, non-athletic field and undisturbed soil areas to establish grades, blend the new landscape into the woodline and as backfill for new general lawn or plantings.

- C. Subgrade or over-compacted horticultural soils at periphery and general lawn areas shall be de-compacted and recompressed per Specification prior to placing soils or re-planting.
- D. When working within or adjacent to the wood line, Contractor shall use manual tools, air spade or other minimally invasive excavation equipment to perform all work within Existing Soil Areas to preserve the integrity of existing root systems.

3.07 PROTECTION

- A. The Contractor shall protect landscape work and materials from damage due to landscape operations, operations by other Contractors or trespassers. Maintain protection during installation until acceptance. Treat, repair or replace damaged Planting Soil installation work immediately.
- B. Provide all means necessary, including fences, to protect all soil areas from compaction and contamination by trash, dust, debris, and any toxic material harmful to plants or humans after placement. Any area that becomes compacted, shall be de-compacted and tilled to the extent determined by the soil scientist and recompressed to the density ranges specified. Any uneven or settled areas shall be filled, re-graded and re-compacted to meet the requirements of this Specification. Soil that becomes contaminated shall be removed and replaced with specified soil material.
- C. Phase the installation of the planting soil such that equipment does not have to travel over already installed planting soil. Use of haul roads is acceptable provided that the haul road is completely re-worked to meet the requirements of this Specification. Under no circumstances shall heavy equipment or trucks be allowed to traverse placed topsoil or prepared subgrade unless said equipment is tracked or has low ground pressure tires.
- D. Apply filter fabric covering and planking or other engineering controls over soil to minimize compaction and collect dust and debris in any area where the Contractor must work after the installation of Planting Soil.
- E. Till compacted Planting Soil and replace Planting Soil that has become contaminated as determined by the Landscape Architect. Planting Soil shall be tilled or replaced by the Contractor at no expense to the Owner.

3.08 CLEAN-UP

- A. During installation, keep pavements clean and work area in an orderly condition.
- B. Keep the site free of trash and debris at all times. Immediately dispose of wrappings or waste materials associated with products necessary for the completion of the work.
- C. All trash and debris shall be removed from the site.
- D. Once installation is complete, remove any excess soil from pavements or embedded in fixtures.

3.09 COORDINATION AND EXCESS MATERIALS

- A. Coordinate activities with other project contractors so that there is no soil disturbance from traffic or other construction activities after placement.
- B. Excess Soil and Materials: Remove the excess soil and materials from the site at no additional cost to the Owner unless otherwise requested.

3.10 ACCEPTANCE/POST INSTALLATION TESTING

- A. Confirm that the final grade of the loam borrow is at the proper finish grade elevations. Adjust grade as required to meet the contours and spot elevations noted on the Plans. Request the presence of the Architect to inspect final grade. Do not proceed with the remaining work of this

Contract until the Architect has given his/her written approval of the final grade.

- B. In-place density testing is required in all areas. Placed lawn and planting soils must be inspected for compaction level by the soil scientist or by the following acceptable Density Test Methods: ASTM D1556 Density of soil and rock in place using Sand Cone Method, ASTM D6938-10 Nuclear Methods, ASTM D2167-08 Rubber Balloon method, after ASTM D698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. Density testing shall be conducted at a minimum of one test for each lift in each plant bed or a minimum of one test for every 1,000 square feet.
- C. Placed Lawn, Planting and Athletic Soils must be capable of infiltrating water at the minimum rate provided in this Specification for each type of planting soil.

END OF SECTION

SECTION 32 92 00
TURF AND GRASSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. All of the Contract Documents, including General and Supplementary Conditions and Division 1 apply to the work of this Section.

1.2 DESCRIPTION OF WORK

- A. The work of this Section consists of providing all labor, equipment, materials, incidental work, and construction methods necessary to perform all planting work and related items as indicated on the Contract Documents and as specified in this Section and includes, but is not limited to, the following:

- 1. Seeding
 - A. General Lawns
 - B. Low Mow Lawns
 - C. Athletic Lawns
 - D. Buffer Zone Planting Mix
 - E. Temporary Wetland Seed Mix
- 2. Compost and Seed over Modified Rockfill
- 3. Sodding
 - A. Softball/Soccer Field (Bid Alt)
 - B. New Softball Field (Bid Alt)
 - C. Baseball Field (Bid Alt)
 - D. Football Field (Base Bid)
- 4. Installation of erosion control blanket and turf reinforcement mat
- 5. Inspection and acceptance
- 6. Cleaning and protection

- B. Sustainable Building Requirements:

- 1. The Contractor is to implement practices and procedures to meet the project's sustainable performance goals, which include achieving LEED v4 Silver certification based on USGBC's "LEED Version 4 for Building Design and Construction: Schools" (LEED v4 BD+C: Schools).
- 2. The work of this Section includes responding to Architect or Contractor requests for additional information or product data and may be required following initial Green Building Certification Institute (GBCI) review of LEED Application.
- 3. Product substitution requests are subject to additional LEED submittal requirements including, but not limited to, Environmental Product Declarations (EPD), Health Product Declarations (HPD), and General Emissions Testing.

1.3 RELATED WORK

- A. Carefully examine the site and all of the Contract Documents for requirements that affect the work of this Section. No claim for additional costs will be allowed because of lack of full knowledge of existing conditions. Other specifications sections that directly relate to the work of this Section include, but are not limited to, the following:

- 1. Section 024113 - Site Preparation

2. Section 312000 – Earth Moving
 3. Section 312500 – Erosion and Sedimentation Controls
 4. Section 323000 - Site Improvements
 5. Section 328400 - Irrigation
 6. Section 329115 – Planting Soils
 7. Section 329100 – Loam and Planting Preparation.
- B. The work of this Section shall be coordinated with that of other trades affecting, or affected by, this work, as necessary to assure the steady progress of all work of the Contract.
1. The planting subcontractor shall become fully acquainted with the nature and requirements of the project including the location of all underground utilities prior to starting the work of this Section.

1.4 SUBMITTALS

- A. Submit the qualifications of the athletic field sports subcontractor meeting or exceeding the minimum requirements specified under 1.6 Quality Assurance. Submittal shall include the following information regarding the completed projects: project name, description, construction cost, date completed, name of the contractor's supervisor who managed the project, name and contact information for the project owner. Submittal shall also include the resume of the supervisor proposed for this project and the pesticide applicator's license for the individual who will be performing pesticide applications on this project.
- B. Submit the Massachusetts Certified Landscape Professional certificate for the landscape foreman who will be performing the daily supervision of the landscape installation.
- C. Material Samples and testing:
1. Provide full analysis of existing on-site loam, and off-site loam source from a laboratory that has been approved in writing by the Architect. Sampling and testing shall be as specified and performed under the work of Section 329115 – Planting Soils.
 2. Provide manufacturers' certified analysis for soil amendments and fertilizers to meet the requirements of this Section, Turf and Grasses.
 4. Provide certified analysis for seed mixtures required including percentages of purity, germination and weed seed.
 5. Provide current catalog cuts and specifications for incorporating mulch and soil stabilizer for hydroseed mix.
 6. Product Data
- D. Sod Submittals:
1. Installer qualifications (company and foreman)
 2. Source
 3. Sod physical properties meeting spec
 4. Independent testing results on soil, NRCS classification AND particle size analysis as percent passing as well as percent sand and fines with sub-fractions.
 5. Biochar product data
- E. Close out: Submit landscape maintenance manual under section 329000 Planting. Turf and grasses shall be incorporated into this overall project manual.

1.5 REGULATORY REQUIREMENTS

- A. Strictly comply with all applicable codes, regulations and requirements having jurisdiction.
- B. All fertilizer and pesticide applications shall be performed by a licensed applicator in strict conformance with all local, state and federal regulations. Notify the Architect at least two (2) weeks prior to scheduled date of application.

1.6 QUALITY ASSURANCE

- A. All work shall be performed by experienced landscape professionals familiar with planting procedures and under the full-time supervision of a foreman who is a Massachusetts Certified Landscape Professional (MCLP).
- B. Fine grading, sodding and maintenance of athletic field lawn and softball/baseball field surfacing shall be performed by a subcontractor specializing in the construction of natural grass athletic fields having been in business for at least 10 years and successfully completed a minimum of 10 natural grass field installations of comparable scope and size within the past 5 years.
- C. Analysis of Materials: For each type of packaged material required for the work of this Section, provide manufacturers' certified analysis.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Packaged Materials: Deliver packaged materials in manufacturer's original unopened containers showing weight, analysis, and name of manufacturer. Comply with manufacturer's instructions and recommendations for storage and handling. Protect all materials from damage, deterioration, injury, and theft while stored at the site.

1.8 EXAMINATION OF CONDITIONS

- A. All areas to be seeded or sodded shall be inspected by the Contractor prior to starting work and any incorrect grading or inadequate drainage shall be reported to the Architect prior to beginning work.

PART 2 - PRODUCTS

2.1 PLANTING SOIL

- A. Planting soil shall be furnished and installed under the work of Section 329100, Loam and Planting Preparation and loam amendments required by the test results and the work of this Section including but not limited to humus, fertilizers and limestone shall be applied separately at the required rates to the rough graded loam and shall be thoroughly and evenly incorporated to the full depth of the in-place loam. Apply approved limestone in sufficient quantity to bring the acidity of the loam to pH 6.5.

2.2 SOIL ADDITIVES

- A. Soil additives shall be specified, provided, and installed under the work of Section 329100 Loam and Planting Preparation.

2.3 SEED MIXES

- A. Seed Material: Provide fresh, clean, new-crop seed complying with tolerance for purity

and germination establish by Official Seed Analysis of North America. Seed shall be composed of the following varieties that shall be mixed in the proportions stated and shall test to minimum percentages of purity and germination. Deliver seed in fully labeled, standard, sealed containers. Seed that has become wet, moldy, or otherwise damaged, will not be accepted.

B. General Lawns shall have the following seed mixture composition:

Common Name	Proportion By Weight	Percent Purity	Percent Germination
Cochise IV Fescue	80%	95%	90%
Fiesta 4 Perennial Ryegrass	10%	95%	90%
Impact Kentucky Bluegrass	10%	85%	90%

1. All varieties shall be within the top 50 percent and 25 percent respectively, of varieties tested in National Turfgrass Evaluation Program, or currently recommended as low maintenance varieties by University of Massachusetts or the University of Rhode Island.
2. The seeding rate for the seed mix shall be 6 pound per 1,000 square feet.
3. Seed used for overseeding as specified herein shall be Perennial Ryegrass having 95% purity and 90% germination

C. Low Mow Lawns shall have the following seed mixture composition:

Common Name	Proportion By Weight	Percent Purity	Percent Germination
Marco Polo Sheep Fescue	25%	95%	90%
Reliant IV Hard Fescue	25%	95%	90%
Viking H2O Hard Fescue	25%	95%	90%
Azure Sheep Fescue	25%	95%	90%

1. Fescue blend shall be a Fescue mix appropriate for full-sun and shade exposure consisting minimum of 4 varieties. The blend shall be Natural Perfection from Colonial Seed Company Windsor, CT 413-355-0200 or approved equal. Seed mix rate shall be at 4# per 1000 SF for fescue lawn areas.

D. Athletic Lawns shall have the following seed mixture composition:

Common Name	Proportion By Weight	Percent Purity	Percent Germination
Kentucky Bluegrass (including at least three improved varieties to be approved by Landscape Architect)	80%	95%	90%
Perennial Ryegrass	20%	95%	90%

1. Bluegrass and ryegrass varieties shall be within the top 50 percent and 25 percent respectively, of varieties tested in National Turfgrass Evaluation Program, or currently recommended as low maintenance varieties by University of Massachusetts or the University of Rhode Island.
2. Seeding rate shall be 4 pounds per 1,000 square feet.

E. Buffer Zone Planting Mix shall have the following seed mixture composition:

Botanical Name	Common Name
<i>Elymus canadensis</i>	Canada Wild Rye
<i>Festuca rubra</i>	Red Fescue
<i>Lolium multiflorum</i>	Annual Ryegrass
<i>Lolium perenne</i>	Perennial Ryegrass
<i>Schizachyrium scoparium</i>	Little Bluestem
<i>Panicum virgatum</i>	Switch Grass
<i>Sorghastrum nutans</i>	Indian Grass

1. Seed mix shall be "New England Erosion Control/Restoration Mix for Dry Sites" or equivalent by New England Wetland Plants, Inc, 820 West Street, Amherst, MA 01002, phone: 413-548-8000, www.newwp.com or approved equal having a similar composition of native grasses suited for dry, upland restoration sites.
2. Seed mix rate application shall be 35 lbs. per acre if sown in fall, or 30 lbs. per acre if sown in the Spring/Summer season.
3. Additional cover crop during establishment phase: for spring planting, use a cover crop of spring oats applied at a rate of 30 lbs/acre. For fall planting, use a cover crop of grain rye, applied at a rate of 30 lbs/acre.

F. Temporary Wetland Seed Mix: areas of temporary wetland alteration will be restored in-kind at the direction of the supervising wetland scientist. Temporary alteration areas where soil has been disturbed will be restored by establishing natural wetland soil profiles using a wetland topsoil suitable for wetland replication areas and seeding with a wetland seed mix, as designated by the wetland scientist, and/or in-kind replacement of native herbaceous plants, shrubs and/or trees. Temporary alteration areas where only vegetation has been removed or disturbed also will be seeded with the wetland seed mix and/or in-kind replacement of native herbaceous plants, shrubs and/or trees. Seeded areas shall be stabilized via hydro-seeding, straw mulch, and/or erosion control blankets at the direction of the wetland specialist.

2.4 COMPOST AND SEED OVER MODIFIED ROCKFILL

A. Blown in compost and seed mixture shall include the following components:

1. Compost as specified under Section 329100 Loam and Planting Preparation
2. Terra-Sorb 200G Hydrogel Seedcoat, fine grade by Plant Health Care, Inc. www.planthealthcare.com, or equal.
3. Dry-tack product shall be Soilfloc DryTack 100D by Aqua Ben Corporation <https://www.aquaben.com> or equal.
4. Buffer Zone Planting Mix as specified herein in 2.3.E.

2.5 SOD

A. TPI, Certified Turfgrass Sod quality; nursery-grown, cultivated grass sod with strong fibrous root system, free of stones, burned or bare spots; containing no more than 5 weeds per 1000 sq. ft. Minimum age of 18 months, with root development that will support its own weight without tearing when suspended vertically by holding the upper two corners. Sod shall be live, fresh and of suitable character for the purpose intended and for the soil on which it will be placed. Sods shall be thick enough to contain all natural roots without mutilation. Sod shall be grown on a sand-based soil profile compatible with

athletic field loam specified under Section 329100 – Loam and Planting Preparation. Sod shall be nursery grown from the following seed mixtures and in accordance with percentages as specified:

Common Name	Proportion Weight	Percent Purity	Percent Germination
Midnight Star Kentucky Blue Grass	<u>20%</u>	95%	90%
America Kentucky Blue Grass	<u>20%</u>	95%	90%
Black Beauty Tall Fescue (3-way blend)	60%	95%	90%

1. Sod Material Source shall be Tuckahoe Turf Farms, Berwick, ME tel 1-800-556-6985 or approved equal; contact Peter Debrusk 603-819-9700.
2. See section 329100 Loam and Planting Preparation for specific requirements regarding the soil grain size distribution in which the sod is grown.

- B. Sod shall be machine cut from an established sod farm specializing in the production and harvesting of top quality, grass turf products. Sod shall be machine cut at a uniform soil thickness of 3/4-inch +/- 1/4 inch, at the time of cutting. Measurement for thickness shall exclude top growth and thatch. Individual pieces of sod shall be cut to the supplier's standard width and length. Maximum allowable deviation from standard widths and lengths shall be 5 percent. Broken pads and torn or uneven ends will not be acceptable. Sod shall be at least one year old from time of original seeding.
- C. Sod shall be free of grass species other than those specified in this section. Sod shall be free of weeds.
- D. Sod shall be furnished and installed as either double 24" or single 48" rolls, and substrate compatible with existing/proposed soils.
 1. Install using machinery with Low ground pressure tracked equipment suited for this type of mechanical installation.
- E. Sod shall be harvested, delivered and installed within a period of 36 hours. Soil on sod pads shall be kept moist at all times.
- F. Sod delivered to the construction site which does not conform to the requirements of this section will be rejected by the Landscape Architect and shall be removed from the site by the Contractor at no additional cost to the Owner. Sod found to contain unacceptable levels of unspecified grass species or weed species at any time up to and including Final Acceptance will be rejected by the Landscape Architect. Contractor shall remove such sod from the site at no additional cost to the Owner. Contractor shall replace unacceptable sod with new, approved sod at no additional cost to the Owner. The Landscape Architect shall be the sole judge of what constitutes acceptable or unacceptable levels of unspecified grass species or weed species.

2.6 FERTILIZERS

- A. Fertilizer shall be a commercial product complying with the State and United States

fertilizer laws Deliver to the site in the original unopened containers that shall bear the manufacturer's certificate of compliance covering analysis. Fertilizer shall contain not less than the percentages of weight of ingredients as recommended by the soil analysis.

- B. Nitrogen fertilizer shall be slowly soluble urea formaldehyde, methylene urea, or isobutylidene diurea; or slow-release sulfur-coated urea.
- C. Phosphorus shall be superphosphate or triple superphosphate.
- D. Potassium shall be sulfate of potash, K₂SO₄.
- E. Salt indexes per unit of nutrient for nitrogen, phosphorous, and potassium shall be less than 1.0 when compared to sodium nitrate (6.3).

2.7 LIMESTONE

- A. Ground limestone for adjustment of loam borrow pH shall contain not less than 85 percent of total carbonates and shall be ground to such fineness that 40 percent will pass through 100 mesh sieve and 95 percent will pass through a 20-mesh sieve. Contractor shall be aware of loam borrow pH and the amount of lime needed to adjust pH to specification in accordance with testing lab recommendations.

2.8 WATER

- A. Water: shall be furnished by the Contractor from a legal off-site source via water truck and be suitable for irrigation, free of toxic ingredients. Sources of water at or near the site that are made available to the Contractor are a convenience to the Contractor. Limitations of site water sources shall be supplemented by off-site sources at the Contractor's expense to meet the maintenance requirements of this Section. Any municipal fees associated with providing water for this work shall be borne by the Contractor.

- 1. Watering Equipment: The Contractor shall furnish sufficient watering equipment to distribute water evenly with complete coverage daily to all non-irrigated seeded areas.

2.9 STRAW

- A. Straw for mulch at seeded areas shall be mowings of acceptable herbaceous growth reasonably free from noxious weeds or woody stems and shall be reasonably dry. No salt hay shall be used.

2.10 HYDRAULIC WOOD FIBER MULCH

- A. Hydraulic Wood Fiber Mulch: shall be derived from natural, clean, whole woodchips. Fiber shall not be produced from recycled material such as sawdust, paper, or cardboard fiber. It shall be dyed green to contrast with the soil on which it is to be applied. Fiber shall have a water holding capacity of not less than 31.5 ounces of water per 3.5 ounces of fiber. The rate of application for wood fiber mulch shall be in accordance with manufacturer's guidelines.

2.11 EROSION CONTROL MAT

- A. The erosion control blanket shall be a machine-produced mat of 100% agricultural straw with a functional longevity of up to 12 months. The blanket shall be of consistent

thickness with the straw evenly distributed over the entire area of the mat. The blanket shall be covered on the top and bottom sides with a 100% biodegradable woven natural fiber netting.

- B. The netting shall consist of machine directional strands formed from two intertwined yarns with cross directional strands interwoven through the twisted machine strands (commonly referred to as a Leno weave) to form an approximate 0.50 x 1.0 in. (1.27 x 2.54 cm) mesh.
- C. The blanket shall be sewn together on 1.50-inch (3.81 cm) centers with degradable thread. The blanket shall be manufactured with a colored thread stitched along both outer edges (approximately 2-5 inches [5-12.5 cm] from the edge) as an overlap guide for adjacent mats.
- D. The straw erosion control blanket shall be S150BN as manufactured by North American Green, or Architect approved equal.
- E. The erosion control blanket shall have the following properties:
 - 1. Material Content:

Matrix	100% Straw Fiber (0.50 lb/yd ²)
Netting	Top and Bottom: Leno woven 100% biodegradable organic jute
Thread	Biodegradable
 - 2. Physical Specifications (per roll):

Width	8.0 ft
Length	112.0 ft
Weight	65.28 lbs
Area	100.00 yds ²
- F. Erosion control mat shall be installed on all seeded slopes 3h:1v or greater.

2.12 TURF REINFORCEMENT MAT

- A. Shall be North American Green Vmax SC250 or approved equal. www.nagreen.comTurf
- B. Shall be a 70% straw and 30% coconut fiber composition with UV stabilized polypropylene netting.
- C. TRM be installed at all vegetated swales and associated side slopes in accordance with manufacturers recommendations.

2.13 HERBICIDES, INSECTICIDES, PESTICIDES and CHEMICALS

- A. Provide herbicides, fungicides and insecticides as needed for effective pest control. All chemicals shall be approved by the Massachusetts Department of Food and Agriculture for the intended uses and application rates.
- B. Provide post emergent crab grass control throughout the maintenance period to ensure a germinated and mown lawn free of crab grass.

2.14 BIOCHAR

- A. Shall be 100% coconut shell derived biochar, manufactured and packaged for use as a

horticultural soil amendment.

- B. Biochar shall be Cool Terra Organic by Cool Planet Camarillo, CA tel 888-564-9332 or approved equal.

PART 3 - EXECUTION

3.1 GENERAL

- A. All areas within the Limit of Work lines not required to be otherwise developed shall be seeded or sodded as shown in the Contract Documents. The Contractor shall restore all lawn areas disturbed because of this Contract with specified loam and seed or sod, as directed by Owner, whether within or outside the Limit of Work line.

3.2 PREPARATION OF SUBGRADE AND SPREADING OF LOAM

- A. Preparation of subgrade and spreading of loam shall be specified, and performed under the work of Section 329100 – Loam and Planting Preparation
- B. Verify all amending and scarification specified under 329100 has been completed prior to starting any seeding work.

3.3 FINE GRADING

- A. Fine grading shall be specified, and performed under the work of Section 329100 – Loam and Planting Preparation
- B. Verify that all grades are within +/- 1 inch of required finished grades prior to starting any seeding work.

3.4 SEEDING: LAWN AREAS

- A. Contractor shall obtain Landscape Architect's written approval of fine grading and be preparation before doing any seeding work.
- B. Seeding shall be done immediately after fine grading provided the seedbed has remained in a friable condition and has not become muddy or hard. If it has become hard, it shall be tilled to a friable condition and fine graded again.
- C. The season for seeding shall be from April 1 to May 31 and from August 15 to October 15. Spring seeding will require a 20% higher seeding rate. The actual planting of seed shall be done, however, only during periods within this season which are normal for such work as determined by weather conditions and by accepted practice in this locality. To prevent loss of soil via water and wind erosion and to prevent the flow of sediment, fertilizer, and pesticides onto roadways, sidewalks, and into catch basins, seed loam areas within 5 Days of spreading the loam.
- D. Sow seed using a spreader or hydroseeder (except at athletic lawn). Do not seed when wind velocity exceeds 5 miles per hour. Distribute seed evenly over entire area by sowing equal quantity of seed specified or scheduled. Apply seed at one half the rate in two directions at right angles to each other. Roll the seeded areas lightly and water with a fine spray.
 - 1. If Hydroseeding Method will be used, furnish a certified statement prior to installation stating the number of pounds of materials to be used per 100 gallons of water. This statement shall also specify the number of square feet of hydroseeding that can be

covered with the quantity of solution in the hydroseeder.

2. Hydroseed with wood cellulose fiber mulch at a rate of 46 pounds per 1,000 square feet or 2000 pounds per acre.
 3. For the hydroseeding process, a mobile tank with a capacity of at least 500 gallons shall be filled with water and the mixture noted above in the specified proportions. The resulting slurry shall be thoroughly mixed by means of positive agitation in the tank. Apply the slurry by a centrifugal pump using the hose application techniques from the mobile tank. Only hose application shall be permitted. At no time shall the mobile tank or tank truck be allowed onto the prepared hydroseed beds. The hose shall be equipped with a nozzle of a proper design to ensure even distribution of the hydroseeding slurry over the area to be hydroseeded and shall be operated by a person thoroughly familiar with this type of seeding operation.
- E. Athletic Lawn: Sow seed between August 15 to October 15 using a Charterhouse speed seeder, Brillion drill seeder or equivalent machine. Spring seeding of athletic fields is not acceptable. Distribute seed evenly over entire area by injecting equal quantity of seed specified. Apply seed at one half the rate in two directions at right angles. Distribute seed evenly over entire area by sowing equal quantity of seed specified. Water with a fine spray.
- F. For slopes 3:1 and greater and were indicated on the plan, erosion control mat is required and shall be furnished and installed immediately following fine grading of topsoil.
- G. Install straw mulch or hydraulic wood fiber mulch in a separate application from seeding installation. Install mulch immediately after fine grading topsoil and seeding. Combining seed and mulch together in one hydroseeding application is not acceptable.
- H. After the grass has germinated, all areas and parts of areas that fail to show a uniform stand of grass, for any reason whatsoever, shall be reseeded and such areas and parts of areas shall be reseeded repeatedly until all areas are covered with a uniform germination.

3.5 COMPOST AND SEED OVER MODIFIED ROCKFILL

- A. Approved compost, dry-tack, terrasorb and seed mixture shall be blended together and blown onto the existing slope where indicated on the Planting Plan to achieve an installed thickness shall be 3 to 4 inches.
- B. Incorporate seed quantity within the mix to achieve twice the seeding rate specified herein.
- C. Incorporate dry-tack and terrasorb in accordance with the manufacturers' recommendations.
- D. Maintain slope in continuous moist condition to achieve uniform germination.
- E. Uneven germination shall immediately be reseeded with the same blend.
- F. Slope shall be watered at a minimum of 2 times per week through September during the year of establishment.

3.5 SODDING

- A. Contractor shall obtain Landscape Architect's written approval of fine grading and surface preparation before doing any sodding work.
- B. Prior to sodding, cast or spread specified biochar product at recommend rate and evenly across area to be sodded and in accordance with the manufacturers recommendations.
- C. The season for sodding shall be from shall be from April 1 to June 1 and August 15 to November 1. The actual lawn construction work shall be done, however, only during

periods within this season that are normal for such work as determined by weather conditions and by accepted practice in this locality. At his option, and on his own responsibility, the Contractor may proceed under unseasonable conditions without additional compensation, but subject to Landscape Architect's approval of time and methods.

- D. Immediately prior to sodding operations, the loam bed shall be lightly scratched with a fine-toothed harrow or hand rake to provide a slightly roughened surface to accept the sodding application.
- E. The soil on which the sod is laid shall be reasonably moist and shall be watered, if necessary. The sod shall be laid smoothly, edge to edge, and where continuous or solid sodding is called for on the plans sod shall be laid with the longest dimension parallel to the contours. Sodding shall start at the base of slopes and progress upwards in continuous parallel rows. Vertical joints between sods shall be staggered. Installation tolerance - tightly - butted seams without overlap or gap. Immediately after laying, press the sod firmly into contact with the soil bed by tamping, rolling, or by other approved methods so as to eliminate all air pockets. Provide true and even surfaces, ensure knitting and protect all exposed sod edges, but without displacement of the sod or deformation of the sod surface.

3.6 LAWN MAINTENANCE

- A. Low Mow Lawn areas to be mowed seasonally.
 - 1. Low Mow Lawn areas indicated on the Planting Plan shall be mowed two times per year as directed by the Landscape Architect. The intent of this limited mowing is to allow the natural character of the specified low mow fescue grass to mature and go to seed while controlling tall weeds and preventing woody plant establishment.
 - 2. The Contractor shall maintain all seeded areas immediately after seeding. The Contractor is responsible for the initial establishment of new seedings and to request the Architect's approval of successful uniform germination to start the specified maintenance period. After acceptance of lawn germination, the Contractor shall maintain fescue lawn areas for a minimum of 90 days within the active growing season. Once grass growth has slowed due to heat or cold dormancy, the maintenance period shall continue over to the next growing season. A level of maintenance not meeting the requirements for proper establishment may require the maintenance period to be extended as determined by the Architect.
 - 3. Maintenance shall consist of watering, weeding, repair of ruts and erosion, repair of protective devices and reseeding.
 - 4. Contractor to Supply Water: The Contractor shall include in his base bid costs for daily and, if necessary, continuous watering of all seeded areas during a normal eight hour working day to maintain the seed bed in a continuous moist condition satisfactory for good germination and development. Control weeds in a legal manner as necessary to maintain seeded areas at 98% weed free.
 - 5. Maintenance shall include all temporary protection fences, barriers and signs and all other work, tools and equipment incidental to proper maintenance.
- B. General Lawn areas to be mowed regularly.
 - 1. The Contractor shall maintain all seeded lawn areas immediately after seeding. The

Contractor is responsible for the initial establishment of new seedings and to request the Architect's approval of successful uniform germination at least 2 weeks prior to the first mowing. After acceptance of lawn germination, the Contractor shall maintain lawn areas for a minimum of 60 days within the active growing season. Once grass growth has slowed due to heat or cold dormancy, the maintenance period shall continue over to the next growing season. A level of maintenance not meeting the requirements for proper turfgrass establishment may require the maintenance period to be extended as determined by the Architect.

2. Maintenance shall consist of watering, weeding, mowing, repair of ruts and erosion, repair of protective devices and reseeded.
3. Contractor to Supply Water: The Contractor shall include in his base bid costs for daily and, if necessary, continuous watering of all grass areas during a normal eight hour working day to maintain the seed bed in a continuous moist condition satisfactory for good germination and turfgrass development. Control weeds in a legal manner as necessary to maintain grass at 98% weed free.
4. The Contractor shall keep lawn mowed until Acceptance by cutting to a height of 2.5 inches when growth reaches 3.5 inches or as directed by the Landscape Architect.
5. At each mowing, all edges of walks, drives, plant beds and other border conditions shall be edge trimmed by hand or machine to produce straight and uniform edge conditions at the prescribed height.
6. Remove and discard from paved areas only clippings and debris generated by each mowing and edging operation legally off-site. Landscape Architect, if practical and aesthetic, may allow sweeping (not blowing) clippings back into grass. Mowers shall be equipped with mulching blades. Do not remove from grass areas any clippings that have been generated by mowing operations. Do not mow grass when wet.
7. Maintenance shall include all temporary protection fences, barriers and signs and all other work, tools and equipment incidental to proper maintenance.
8. The Contractor shall be responsible for all maintenance of lawns necessary to meet the acceptance criteria specified herein.
9. The Contractor shall be responsible for providing mowing and maintenance of lawn areas in existence prior to construction that are made inaccessible to owner during construction, including areas outside of the Limit of Work line.

C. Seeded Athletic Fields:

1. Athletic field lawn shall be maintained for a minimum of one year following acceptance of uniform germination.
2. At athletic field areas: After lawn establishment perform one deep tine aeration on mature seeded turfgrass to a minimum depth of 8 inches at 3 inch spacing using a Verti-Drain 7521 or equivalent machine.
3. At least one slice seeding shall be performed following aeration using the approved seed mixture applied at half the recommended rate per pass with 2 passes at 90 degree directions.

4. The Contractor shall keep all Lawn mowed until Acceptance of the contract by cutting to a height of 2.5 inches when growth reaches 3.5 inches or as directed by the Landscape Architect.
5. At each mowing, all edges at fences and individual objects shall be trimmed by hand or machine to produce clean and uniform edge conditions.
6. Remove and discard clippings and debris generated by each mowing and edging operation legally off-site. Mowers shall be equipped with mulching blades. Do not remove from grass areas any clippings that have been generated by mowing operations. Do not mow grass when wet.

D. Sodded Athletic Fields:

1. Athletic field lawn shall be maintained for a minimum of 90 days following placement of sod.
2. 6-8 weeks after sod placement, perform one deep tine aeration on mature seeded turfgrass to a minimum depth of 8 inches at 3 inches spacing using a Verti-Drain 7521 or equivalent machine.
3. At least one slice seeding shall be performed following aeration using the approved seed mixture applied at half the recommended rate per pass with 2 passes at 90-degree directions.
4. The Contractor shall keep all sodded athletic field lawn mower until Acceptance of the contract by cutting to a height of 2.5 inches when growth reaches 3.5 inches or as directed by the Landscape Architect.
5. At each mowing, all edges at fences and individual objects shall be trimmed by hand or machine to produce clean and uniform edge conditions.
6. Remove and discard clippings and debris generated by each mowing and edging operation legally off-site. Mowers shall be equipped with mulching blades. Do not remove from grass areas any clippings that have been generated by mowing operations. Do not mow grass when wet.

- D. Fertilizing all Lawn Areas: The first application of fertilizer is specified, provided, performed and paid for under the Section 329100 Loam and Planting Preparation. A second application of fertilizer shall be applied to seeded areas at the time of the first mowing and shall be performed and paid for under this section, TURF AND GRASSES. This second application shall be applied at a rate that ensures that one-half pound of nitrogen is applied per 1,000 square feet. Phosphorus and potassium shall be applied proportionally in accordance with the recommendations of the soil tests and the quantities previously integrated into the soil during the first application. A third application of nitrogen fertilizer shall be applied to seeded areas approximately two months after the second application and shall be paid for under this section, TURFS AND GRASSES. This third application shall correspond to the following application rates dependent upon the month of application.

1. May 1-15: Apply 1.0 pound of nitrogen per 1,000 square feet.
2. June 15-30: Apply 1.0 pound of nitrogen per 1,000 square feet.
3. August 15 through September 15: Apply 1.0 pound of nitrogen per 1,000 square feet.
4. November 1-15: Apply 1.5 pounds of nitrogen per 1,000 square feet.

Nitrogen fertilizer shall be composed of 50 percent slowly soluble or slow-release nitrogen fertilizer.

3.7 REVIEW AND ACCEPTANCE

- A. At the end of the maintenance period, athletic field, fescue lawn and irrigated lawn seeded areas shall have a close stand of grass as defined above with no weeds present and no bare spots greater than 3 inches in diameter over greater than 5 percent of the overall seeded area. At least 90 percent of the grass established shall be permanent grass species. If seeded areas are deficient, the Contractor's responsibility for maintenance of all seeded areas shall be extended until deficiencies are corrected. Seeded areas to be corrected shall be prepared and reseeded in accordance with the requirements of this Section.
- B. At the time of acceptance, the Contractor shall remove temporary barriers used to protect lawn areas.
- C. The Architect shall review the lawns upon written request by the Contractor. The request shall be received at least ten days before the anticipated date of review.
- D. The conditions of lawns will be noted and determination made by the Architect whether maintenance shall continue in any part. When acceptance is made in writing to the Contractor, the Contractor's responsibility for maintenance of lawns or parts of lawns shall cease.
- E. Areas of lawn not meeting the criteria for establishment specified herein will be noted. Remedial work and maintenance shall continue until the lawn is accepted by the Owner.

3.8 CLEANING AND PROTECTION

- A. During operations, keep pavements clean and work area in an orderly condition. Protect lawns from damage by other contractors and trades and trespassers. After completion of the work, the Contractor shall remove all debris, materials, rubbish, excess dirt, etc. from the site and dispose of them in a legal manner. The premises shall be left clean and presentable to the satisfaction of the Architect.

END OF SECTION

SECTION 330131
RELINING SEWER AND DRAIN PIPES

PART 1 – GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all SECTIONS within DIVISION 1-GENERAL REQUIREMENTS, which are hereby made a part of this Section of Specifications.

1.2 DESCRIPTION OF WORK

- A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:
 - 1. Rehabilitation of existing deteriorated sewers and drains as indicated in the contract documents by means of the installation of cured-in-place (CIPP) or “fold and form” pipe lining that renders each pipe segment free of infiltration/inflow and structural defects.
 - 2. Liners, including all thermosetting liners, must take the shape of the existing pipe after installation and shall not leave a gap or annular space between the liner and the pipe.
 - 3. The pipe rehabilitation method shall not require excavation for the installation of the liner or to reopen existing service connections.
 - 4. Cured-in-place liners and fold and form liners shall be cured using hot water, steam or ultra violet light.
 - 5. Liners shall be designed in accordance with ASTM F1216 for fully deteriorated pipe.
- B. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
 - 1. Section 333001-SANITARY SEWERAGE UTILITIES BUILDING REMAINDER PACKAGE for sanitary sewerage system requirements.
 - 2. Section 334001-STORM DRAINAGE UTILITIES BUILDING REMAINDER PACKAGE for storm drainage system requirements.
 - 3. Section 221316-SANITARY WASTE AND VENT PIPING for building sanitary drain and vent requirements.

1.3 SUBMITTALS

- A. Refer to Section 013300 – SUBMITTAL PROCEDURES, for submitted provisions and procedures.
- B. The Contractor shall submit detailed design calculations of the liner including liner material, sizes of material, specification of materials, shop drawings including any special method or procedures or any other information deemed necessary by the Engineer including the following:
 - 1. A statement containing the lining contractor’s name, address, and years of experience in installing the type of lining proposed, and at least three references relating to the lining projects of the same type being proposed under this Contract.

2. A statement identifying the rehabilitation process/product by trade name as well as by the industry known generic name. This statement shall include a brief description of the material composition, physical properties, and manufacturer's recommendation for handling, storing and repair of pipe and fittings, as well as the process used to install and cure the liner.
3. A certification that the Contractor is an approved licensed installer of the rehabilitation method.
4. A letter of certification from the liner manufacturer in which all physical and chemical properties of the material to be used meets or exceeds the requirements of these specifications. These properties shall at least include the following:
 - a. Instantaneous Tensile Strength (yield) in psi.
 - b. Long Term (50-yr loadings) Tensile Strength (yield) in psi.
 - c. Instantaneous Tensile Strength (break) in psi.
 - d. Long Term (50-yr loadings) Tensile Strength (break) in psi.
 - e. Instantaneous Flexural Modulus in psi.
 - f. Long Term Flexural Modulus in psi. Long Term Flexural Modulus is defined as smaller of creep modulus or continuous loading modulus of elasticity (50 year).
5. Name and address of the resin manufacturer.
6. Detailed design calculations, including assumptions upon which the calculations are based. The calculations shall consider traffic loading; earth loads, hydrostatic loads, and shall be based on a long-term basis and shall include applicable technical data sheets. It shall be assumed that the existing pipe will contribute no appreciable strength to the completed lining. These calculations must be stamped by a Registered Professional Engineer in Massachusetts.
7. The selected "liner pipe" shall be designed based upon the following applicable criteria:
 - a. The dead load and live loads for the actual depth of cover.
 - b. Saturated soil conditions using a soil weight of 120 pounds per cubic foot and a coefficient of friction $Ku^1=0.130$.
 - c. Groundwater levels above the top of the pipe equal to actual conditions or stated conditions as indicated in the Contract Documents. Otherwise, it shall be to a height of $\frac{1}{2}$ of the height distance from the crown of the pipe to the street or surface grade.
 - d. Loss of hydraulic capacity shall not exceed 10%.
8. For Fold and Form type liners: the type of seal to be used at the manhole entry point.
9. The manufacturer's heating requirements and curing guidelines.

1.4 REFERENCE STANDARDS

- A. The tube material, resin system and all other materials and installation procedures shall conform to the following documents:
 1. ASTM F-1216 Standard Practice for the Installation of Cured-in-Place Pipe (CIPP) by Inversion Lining.
 2. ASTM F-1743 Rehabilitation of existing pipelines and conduits by pulled-in-place installation of cured-in-place thermo-setting resin pipe.
 3. ASTM D-5813 Cured-in-Place Thermosetting Resin Sewer Pipe.

1.5 EXAMINATION OF SITE AND DOCUMENTS

- A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation on the site.
- B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.6 QUALITY ASSURANCE

- A. Environmental Compliance: Comply with applicable portions of local environmental agency regulations pertaining to sanitary sewerage systems.
- B. Utility Compliance: Comply with the Town of Wakefield Department of Public Works regulations, standards, and guidelines pertaining to sanitary sewerage system installation and inspections.
- C. Manufacturer's Qualifications: Firms regularly engaged in manufacturing of cured-in-place products of type, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than five years.
- D. Installer's Qualifications: Firms with at least five years of successful installation experience in commercial installation of cured-in-place product. In addition, the Installer must have successfully installed at least 100,000 feet of cured-in-place product in wastewater and storm drainage collection systems.

1.7 PROJECT CONDITIONS

- A. Site Information: Perform site inspection and survey, research utility records, and verify existing utility locations and elevations. Verify that relining can be installed in compliance with Contract Drawings and referenced standards.

1.8 SEQUENCING AND SCHEDULING

- A. Coordinate with interior building sanitary sewer and drainage system piping.
- B. Coordinate with other utility work.
- C. The Contractor is responsible for developing a sequence of work to maintain existing services in operation until the new services are operational.
- D. The Contractor is responsible for coordinating and scheduling the inspection of the work by the jurisdictional authority. All permits and inspection costs and fees shall be included in the bid prices and no additional costs will be paid to the Contractor.

PART 2-PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. All materials used in the liner installation shall be industry accepted materials for sewer/drain pipe rehabilitation and to the satisfaction of the Engineer. Liners for cured-in-place pipe shall be felt or fiberglass based or fiberglass based for ultraviolet curing. The lining shall be chemically resistant to internal exposure to sewage containing gases at normal levels for domestic sewage of hydrogen sulfide, carbon monoxide, carbon dioxide, methane, dilute sulfuric acid, external exposure to soil bacteria and any other chemical attack which may be due to materials in the surrounding ground.
- B. The lining shall be continuous over the entire length between adjacent manholes and free as possible from visual defects such as foreign inclusions, dry spots, air bubbles, pinholes, pimples, wrinkles and delamination. The lining shall be impervious and free of any leakage from the surrounding ground or from the ground to the inside of the rehabilitated pipe. Any defects which will affect, in the foreseeable future as determined by the Engineer, the integrity or strength of the lining, shall be repaired or the lining replaced at the Contractor's expense and to the satisfaction of the Engineer.

2.2 LINER REQUIREMENTS

- A. Cured-in-Place Liners shall be manufactured and installed in accordance with ASTM F1216, latest version or ASTM F1743 latest version with the following minimum physical properties:
 - 1. Tensile Strength: 3,000 psi (ASTM D638)
 - 2. Flexural Stress: 4,500 psi (ASTM D790)
 - 3. Modulus of Elasticity: 250,000 psi (ASTM D790)
- B. Fold and Form Liners shall be manufactured and installed in accordance with the following:
 - 1. Polyvinylchloride (PVC) liners shall conform to ASTM D-1784.
 - 2. High-Density Polyethylene (HDPE) liners shall conform to ASTM D-1248
 - 3. The minimum physical properties shall be as follows:
 - a. Tensile Strength: 3,500 psi (ASTM D638)
 - b. Flexure Stress: 4,100 (ASTM D790)
 - c. Flexural Modulus: 135,000 psi (ASTM D790)

2.3 TUBE SECTIONS

- A. Acceptable Materials
 - 1. Fiberglass (cured with ultraviolet light)
 - 2. Felt (cured with hot water)
- B. Tube Characteristics & Standards
 - 1. At the time of manufacture, each lot of glass fiber or felt tube liner shall be inspected for defects and tested in accordance with applicable ASTM standards. At the time of delivery,

- the liner shall be homogeneous throughout, uniform in color, free of cracks, holes, foreign materials, blisters, and deleterious faults.
2. For testing purposes, a production lot shall consist of all liner having the same marking number. It shall include any and all items produced during any given work shift and must be so identified as opposed to previous or future production.
3. The Engineer may at any time direct the manufacturer to obtain compound samples and prepare test specimens in accordance with applicable ASTM standards.
4. An "inner liner" and "outer liner" film must be used for resin control (to prevent resin migration and contamination). The "inner film" and "outer film" must both be certified styrene gas barriers. The "inner liner" film must be removed during the installation process unless it is a permanent part of the system and is made an integral part of the carrier tube by bonding or fusing to the carrier tube.
5. The material shall be manufactured in such a manner as to result in a tight-fitting continuous liner after installation.
6. All wet-out or impregnation of the Tube shall be performed in an EPA-regulated, quality controlled facility. Documentation of EPA permitting must be submitted. No "over the hole" or "on-site" set-out is allowed. For products that are cured with hot water, the wet-out must be conducted within 300 miles of the job site considering the time-sensitive characteristics of thermal-cured products.

C. Fiberglass Tube (Ultraviolet Light Curing Application)

1. The glass fiber tubing shall be seamless and spirally wound, including an exterior and interior film that protects and contains the resin used in the liner. The exterior film shall be provided with an Ultraviolet light blocker foil.
2. The Tube shall consist of a seamless, spirally wound glass fiber that is flexible and has strain values (expandable) of eight (8) to ten (10) percent. The tube shall not have a longitudinal seam, including a stitched seam, stitch-free-weld or bond, or stitch-free overlap. The tube shall be constructed to withstand installation pressures and have sufficient strength to bridge missing pipe sections.
3. The impregnated Tube shall have a uniform thickness, that when compressed at installation pressures will meet or exceed the Design thickness. If voids are present in the host pipe, the design wall thickness must still be met or exceeded.
4. The tube shall be sized such that when installed, it will tightly fit the internal circumference and length of the original pipe.
5. The glass fiber tube shall be saturated with the appropriate resin using a resin bath to allow for the lowest possible amount of air entrapment. Vacuum-suction impregnation methods are not allowed due to the introduction of air using this method. The liner shall then be formed into a spirally wound shape for the purpose of being seamless in its cured state. An inner and outer material shall be added that are both impervious to airborne styrene, with the outer material also having ultraviolet light blocking characteristics. The inner membrane shall be removed after the installation and curing processes are completed.
6. The wall color of the interior pipe surface of CIPP after installation shall be a light reflective color so that a clear detailed examination with closed circuit television inspection equipment may be made.
7. The liner shall be seamless in its cured state to ensure homogeneous physical properties around the circumference of the cured liner.
8. The manufacturer shall test the raw materials and liner materials at various stages of manufacturing on every liner, including taking samples of every finished liner and conducting tests for e-modulus, tensile, wall thickness, and porosity.
9. Fiberglass materials shall be "direct sized" to enhance the fiberglass/resin bond. Certification of this coating and its compatibility with the resin system used is required.

D. Felt Tube (Hot Water Curing Application)

1. The Tube shall consist of one or more layers of absorbent felt fabric and meet the requirements of ASTM F1216 or ASTM F1743, Section 5.
2. For work performed under this specification, the following felt-based carrier tube materials shall be used: Non-woven polyester felt and Non-woven fiberglass filament reinforced polyester felt.
3. The Tube shall be constructed to withstand installation pressures and have sufficient strength to bridge missing pipe while meeting or exceeding the design wall thickness at all pipe locations during installation conditions and pressures.
4. The Tube shall be sized such that when installed will tightly fit the internal circumference and length of the original pipe. Overlapped layers of felt in longitudinal seams that cause lumps in the final product shall not be utilized.
5. The Tube shall be homogeneous across the entire wall thickness containing no intermediate or encapsulated electrometric layers. No material shall be included in the tube that may cause delaminating in the cured liner (CIPP). No dry or unsaturated layers shall be evident.
6. The wall color of the interior pipe surface of CIPP after installation shall be a light reflective color so that a clear detailed examination with closed circuit television inspection equipment shall be made.
7. Seams in the felt tube shall be allowed, but the seams must be stronger than the non-seamed felt. Third-party test data documenting the strength of the seam is required.
8. The manufacturer shall test the raw materials and liner materials at various stages of manufacturing on every liner, including taking samples of every finished liner and conducting tests for e-modulus, tensile, wall thickness, and porosity.
9. The outside of the tube shall be marked for distance at regular intervals along its entire length, not to exceed 5 ft. Such markings shall include the Manufacturer's name or identifying symbol.

2.4 RESIN

- A. The resin system shall be a corrosion resistant polyester or vinyl ester system including all required catalysts, initiators that when cured within the tube create a composite that satisfies the requirements of ASTM F1216, ASTM D5813 and ASTM F1743, the physical properties herein, and those which are to be utilized in the submitted and approved design of the CIPP for this project. The resin shall produce a CIPP that will comply with the structural and chemical resistance requirements of this specification.

PART 3-EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

- A. The liner shall be fabricated to a size that when installed will neatly fit the internal circumference of the pipe to be rehabilitated
- B. The Contractor shall make allowance for any longitudinal or circumferential stretching of the liner during installation. The length of the liner shall be that deemed necessary by the Contractor to efficiently carry out the lining process at the inlet and outlet of the respective manholes.
- C. The Contractor is responsible for verifying all lengths, exact pipe dimensions and sizes in the field before installation. Individual liner runs may be made over manhole to manhole sections as determined in the field by the Contractor and approved by the Engineer.

- D. The pipe sizes indicated on the Contract Documents are normal pipe sizes. The Contractor shall be solely responsible for determining all sizes; shapes, lengths and all other information needed to fabricate the liner. No additional payment shall be made if removal of the liner is necessary or if the liner is unable to be installed due to incorrect sizing by the Contractor.
- E. SAFETY: The Contractor shall carry out his operations in strict accordance with all OSHA and manufacturer's safety requirements
- F. Containment of sewage and site cleanliness is the responsibility of the Contractor. Fines levied by State and Federal agencies in the event of a spill or unapproved discharge shall be the responsibility of the Contractor. Spill cleanup as well as site cleanup shall be conducted by and paid for by the Contractor. Any waste product from lining of the sewer and drain pipes shall be collected and disposed of according to State and Federal laws. All cleanup and associated costs are part of acceptance of the project, without which final payment will not be made.

3.2 PREINSTALLATION

- A. Cleaning of Sewer and Drain Pipe: Prior to lining, it shall be the responsibility of the Contractor to clean debris out of the pipe in order to install the liner.
- B. Inspections of Pipelines: The Contractor shall inspect by closed circuit television the sections of sewer and drain pipes to be relined. Inspections of pipelines shall be performed by experienced personnel trained in locating breaks, obstacles, and service connections by closed circuit television. The interior of the pipeline shall be carefully inspected to determine the location of any conditions which may prevent proper installation. These conditions shall be noted so they can be corrected. The inspection log shall note the precise location of all services. The Engineer shall receive a DVD and log for later reference. If it is unclear whether a service connection is active the Contractor will be responsible for dye testing services to determine if it is active or not. There will be no additional payment for dye testing of services.
- C. Sewer Flow Control: The Contractor shall bypass the flow around the sections of pipe to be lined or as deemed necessary by the Engineer.
 - 1. A line plug shall be inserted into the pipe upstream of the section to be lined. The plug shall be so designed that all or any portion of the sewage can be released. After the work has been completed, flow shall be restored to normal.
 - 2. The by-pass shall be made by plugging an existing upstream manhole if necessary and pumping the sewage into a downstream manhole or adjacent system. When pumping and bypassing is required, the Contractor shall supply the pumps, conduits, and other equipment to divert the flow of sewage around the manhole section in which work is to be performed. The by-pass system shall be of sufficient capacity to handle existing flow plus additional flow that may occur.
 - 3. The Contractor shall be responsible for furnishing the necessary labor and supervision to set up and operate the pumping and by-pass system. If pumping is required on a 24-hour basis, engines shall be equipped in a manner to keep noise to levels below or equal to those required by the Town of Wakefield and the Owner.
 - 4. All bypass systems shall be approved by the Engineer. Approval of the by-pass system by the Engineer shall in no way be construed as relieving the Contractor of any responsibility under this Contract as related to protection of the interest of the Commonwealth or the general public.
 - 5. At the end of each working day, temporary tie-ins shall be made between the rehabilitated section and the existing system and the by-pass plug removed, unless the temporary system is to remain in place as approved by the Engineer.

6. When flow in a sewer line is plugged, blocked, or by-passed, sufficient precautions must be taken to protect the sewer lines from damage that might result from sewer surcharging. Further, precautions must be taken to ensure that sewer flow control operations do not cause flooding or damage to public or private property being served by the sewers involved.
 7. Under no circumstances will the dumping of raw sewage on public or private property or in the municipal streets be allowed.
 8. All costs associated with flow control shall be included with the pipe lining costs and no additional costs will be paid to the Contractor.
- D. Line Obstructions: It shall be the responsibility of the Contractor to clean the line of any obstructions, solids, protruding laterals, or collapsed pipe that will prevent the installation of the liner to the satisfaction of the Engineer.
1. If pre-construction inspection reveals an obstruction, such as a badly misaligned joint, then the Contractor shall make a point repair excavation to uncover and remove or repair the obstruction.
 2. Protruding lateral shall be ground down to the face of the pipe to allow for a tight fitting liner.
 3. Excavations for point repairs and the removal of protruding laterals shall be approved in writing by the Engineer prior to the commencement of the work.
 4. Line obstruction repairs shall be included with the pipe lining costs and no additional costs will be paid to the Contractor.

3.3 INSTALLATION

A. Tube Insertion – Fiberglass/UV Cured Products

1. A slip sheet shall be installed on the bottom half of the pipe prior to liner insertion, for the purpose of smoothing out the bottom of the liner to increase flow characteristics.
2. The lining tube, or outer film, must be inserted into the pipe prior to inserting the liner, unless it is manufactured on the exterior of the liner, which is a normal characteristic of most fiberglass CIPP liners.
3. A constant tension winch shall be used to pull the glass fiber liner into position in the pipe. Once inserted, end plugs shall be used to cap each end of the glass fiber liner to prepare for pressurizing the liner. The end plugs shall be secured with straps to prevent them from being expelled due to pressure. Liner restraints shall be used in manholes.
4. The glass fiber liner shall be cured with UV light sources at a constant inner pressure. When inserting the curing equipment in the liner, care should be taken to not damage the inner film material.
5. The UV light sources shall be assembled according to the manufacturer's specifications for the liner diameter. For the liner to achieve the required water tightness and specified mechanical properties, the following parameters must be controlled during the entire curing process, giving the Engineer a record of the curing parameters over every segment of the entire length of the liner. This demonstrates that the entire liner is cured properly. The recording shall include:
 - a. Curing speed
 - b. Light source working & wattage
 - c. Inner air pressure
 - d. Exothermic (curing) temperature
 - e. Date and time
 - f. Length of liner

6. The recording of the curing parameters shall be accomplished using a computer and data base that are tamper proof. During the curing process, infrared sensors will be used to record curing data that shall be submitted to the Engineer with a post CCTV inspection on DVD.
7. The parameters for curing speed, inner air pressure and wattage are defined in the Quality Tracker UV curing protocol issued by the manufacturer. The optimal curing speed, or travel speed of the energized UV light sources, is determined for each length of liner based on liner diameter, liner thickness, and exothermic reaction temperature.
8. The inner film material should be removed and discarded after curing to provide optimal quality of the final product.
9. Flushing of the cured fiberglass/UV cured CIPP liner (to reduce styrene residual) is required for fiberglass/UV cured CIPP products.

B. Tube Insertion/Inversion – Felt/Hot Water Cured Products

1. The resin impregnated tube shall be transported and stored in a refrigerated truck until it is installed in an existing pipe by using an application of water, air, or cable and winch to properly place the tube between the upstream and downstream manholes.
2. The praline tube, or outer film, shall be inserted into the pipe prior to inserting the liner.
3. The wet out felt tube shall be inserted, or inverted, through an existing manhole or other approved access. Liner installation head pressures (minimum and maximum for hold and cold conditions) shall not be exceeded, regardless of which method of installation (stand pipe, pressure unit, etc.) is used.
4. Using the "Inversion Procedure", the tube end shall initially be turned inside out and attached to a platform ring, standpipe, or as approved. The addition of water will be adjusted to sufficient height/pressure to cause the impregnated tube to invert from manhole to manhole, and hold the tube tight against the existing pipe wall.
5. Using the "Insertion Procedure", the tube is winched into position according to manufacturer's recommendations. The addition of water will be adjusted to sufficient height/pressure to cause the calibration hose to invert from manhole to manhole and hold the tube tight against the existing pipe wall.
6. Liner restraints should be used in manholes.
7. After the installation of the liner is completed, the Contractor shall use hot water system capable of providing the required amount of heat uniformly throughout the section for a complete cure of the resin. All water obtained from a Town of Wakefield or Private fire hydrant shall be metered. The Contractor shall be responsible for obtaining said water meter. An air gap shall be provided between pipes/hose connected to a fire hydrant and a storage tank/equipment used by the Contractor.
8. The curing temperature and duration schedule shall be as recommended by the resin/catalyst system manufacturer.
 - a. The heat source shall be fitted with suitable monitors to gauge the temperature of the incoming and outgoing heat supply.
 - b. The Contractor shall utilize a remote temperature sensing method to ensure adequate curing for every foot of liner in the pipe, considering the possibility of heat sinks. Temperatures monitored at the manholes do not guarantee an adequate representation of the temperatures for every foot of liner.
 - 1) Temperatures from each remote sensing device shall be recorded by a strip-chart recorder on a continuous tape.
 - 2) Graphs of the tape shall reflect readings from start of cure to completion of cure/draining of line.
 - 3) Tapes for each segment shall be submitted upon completion of each section.

- 4) Initial cure may be considered complete when the remote sensing device(s) reflect that the cure temperatures, as recommended by the resin/catalyst system manufacturer, have been achieved.
- 5) Curing temperatures and duration shall comply with submitted data and shall include an adequate "cool down" as recommended by the resin manufacturer.

C. Cool Down

1. The Contractor shall cool the hardened liner to a temperature less than 100 degrees Fahrenheit, in accordance with the resin manufacturer's recommendation, before relieving the water column or pressure.
 - a. Cool water may be added to the water column while maintaining circulation as water is drained from a small hole at the opposite end of the cured-in-place pipe so that a constant water column height is maintained until cool-down is completed.
 - b. Care shall be taken in the release of the water column so that a vacuum will not develop that could damage the newly installed liner.
 - c. Coupon samples shall be obtained for testing.
2. If styrene levels on the surface of the liner exceed EPA or wastewater treatment plant standards for storm water or sanitary sewer pipes (respectively), the Contractor shall flush the line until styrene levels in flush-water are within the appropriate standard.
3. The Contractor shall provide whatever measures are required to prevent the movement or discharge of gases, liquids or solids associated with the liner material and process into adjacent buildings upstream or downstream of the sewer/drain being rehabilitated. The Contractor shall be responsible and liable for any damages or violations associated with such actions. The Contractor shall also be responsible for monitoring and protecting as required the discharge of any byproducts caused by the installation of the liner or the lining process.

D. Post Installation

1. For Fold and Form type liners: After installation of the liner a mechanical type sealing device capable of providing a watertight seal shall be installed at the manhole to seal the liner to the manhole wall. Grouting alone is not acceptable.
2. The type of seal shall be submitted as a shop drawing at the pre-construction meeting.

E. Service Connections

1. After the liner has been completely installed all existing active services shall be reopened.
2. The contractor shall keep precise information from the pre-lining DVD of the location of all services. The Contractor shall review the pre- and post-construction DVD to ensure that all services have been opened.
3. All existing inactive services shall not be reopened. The decision not to reconnect an existing service shall be approved by the Engineer.
4. Branch connections shall be re-opened without excavation, utilizing a remotely controlled cutting device, monitored by a CCTV. The Contractor shall certify a minimum of two complete functional cutters plus key spare components are on the job site before each installation or are in the immediate area of the job site and can be quickly obtained.
5. No additional payment will be made for excavations for the purpose of reopening connections and the Contractor will be responsible for all costs and liability associated with such excavation and restoration work.

6. The Contractor shall be required for a period of two years after the accepted completion of this work, to correct any improperly reopened services or any services which were not reopened.

F. Testing

1. The water tightness of the liner shall be gauged during the installation under a positive head.
2. After the work is completed, the Contractor shall submit a DVD showing the completed work including the restored condition.
3. CIPP samples shall be prepared for each installation designated by the Engineer or approximately 20% of the project's installations. Pipe physical properties shall be tested in accordance with ASTM F-1216 or ASTM F-1743, Section 8, using either method proposed. The flexural properties must meet or exceed the values listed in this specification, Table 1 of ASTM F-1216 or the values submitted to the Engineer by the Contractor for this project's CIPP wall design, whichever is greater.
4. Wall thickness of samples shall be determined as described in paragraph 8.1.6 of ASTM F-1743. The minimum wall thickness at any point shall not be less than 87½ % of the submitted minimum design wall thickness as submitted for this project.
5. Visual inspection of the CIPP shall be in accordance with ASTM F-1743, Section 8.6.

G. Gas and Odor Control

1. The Contractor is responsible for the control of all odors and gases produced as part of the installation and curing of the liner
2. The Contractor shall have an emergency response plan in place in the event of complaints of styrene gas entering a building that includes the proper testing equipment and air removal system. The following items shall be addressed by the Contractor:
 - a. The Contractor shall flush out all pipes affected by the work with clean water immediately after the liner is cured.
 - b. The Contractor shall have at least three 16-inch smoke ejectors available including an external power source.
 - c. If a service is being bypassed, then all openings on the service will be plugged during the curing process.

H. Video Taping

1. After work is completed, the Contractor shall video inspect the rehabilitated pipe sections and submit a DVD showing the rehabilitated sections after rehabilitation including the location of all service connections.

3.4 CLEAN UP

- A. After the installation work has been completed, the Contractor shall clean up the entire project area and restore disturbed areas to as good a condition as existing prior to the work being performed.
- B. The Contractor shall dispose of all excess material and debris not incorporated in the permanent installation.

END OF SECTION

SECTION 331000
WATER UTILITIES

PART 1-GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all SECTIONS within DIVISION 1 – GENERAL REQUIREMENTS, which are hereby made a part of this Section of Specifications.

1.2 DESCRIPTION OF WORK

- A. Provide labor, materials, and equipment necessary to construct the exterior water system complete, including connections to existing pipelines and testing, all as indicated on the Drawings and as specified, including but not limited to the following:
 - 1. Installation of ductile iron pipe, fittings, accessories, and appurtenant work, at the locations and to the lines and grades indicated on the Contract Drawings.
 - 2. The installation of hydrants, gate valves and boxes and concrete thrust blocks.
 - 3. Furnishing and installation of all materials required to connect to existing water mains, replace existing services, install new gate valves, remove existing gate valves, install corporation cocks, saddles, curb stops, service boxes, and abandoning of the existing water system (if applicable), all as shown on the Contract Drawings. All valves, 24 inches and larger shall be butterfly valves. All abandoned pipes shall be cut and capped at the main.
 - 4. In accordance with 528 CMR 11.00, work on the fire protection system, including hydrants and exterior underground piping, shall be performed by a Licensed Fire Protection Sprinkler Systems Contractor. The fire protection exterior underground piping will terminate at the valved tee connection to the water distribution system. The tee and valve will not be considered part of the fire protection system work.
- B. Unless otherwise indicated on the Drawings, exterior water lines shall be installed from a point 10 feet outside the building foundation walls to the potable water source
- C. Related Work: The following items are not included in this Section and will be performed under the designated Sections.
 - 1. Section 312000 – EARTH MOVING for soil materials, excavating, backfilling, and site grading and removal of site utilities.
 - 2. Section 211000 – FIRE PROTECTION for fire protection service piping.
 - 3. Section 221000 – PLUMBING for potable water service piping.

1.3 SUBMITTALS

- A. Refer to Section 013300 – SUBMITTAL PROCEDURES, for submitted provisions and procedures.
 - 1. Descriptive literature showing pipe dimensions, pipe and joint materials and dimensions, and other details for each class or type of pipe or product to be furnished for this contract. All pipe furnished under the contract shall be manufactured in accordance with these Specifications.
 - 2. Product Data: Submit manufacturer's technical product data and installation instructions for potable water system materials and products.

3. Shop Drawings: The Contractor shall submit for review shop drawings or descriptive literature for potable water system, showing piping, fittings, couplings, valves, hydrants, materials, dimensions, restrained joint calculations, joints and other details, blocks, and anchors. All hydrants and valves furnished under the Contract shall be manufactured only in accordance with the Specifications and the approved Shop Drawings.
4. At project closeout, submit record drawings of installed potable water system piping and products, in accordance with requirements of Division 1. As-Built Drawings shall be complete and shall indicate the true measurement and location, horizontal and vertical, of all new construction. As-Built drawings shall be stamped and signed by a Massachusetts Licensed Land Surveyor or Licensed Professional Engineer. The as-built plans shall also be submitted electronically as an AutoCAD drawing file (release 2010 or higher).
5. Maintenance Data: Submit maintenance data and parts lists for water system materials and products. Include this data, product data, shop drawings, and record drawings in maintenance manual in accordance with requirements of Division 1.

1.4 REFERENCE STANDARDS

- A. The following standards are applicable to the work of this Section to the extent referenced herein:
 1. ASTM: American Society for Testing and Materials.
 2. ANSI: American National Standards Institute.
 3. AWWA: American Water Works Association.
 4. AASHTO: American Association of State Highway and Transportation Officials.
 5. Reference is made herein to the Commonwealth of Massachusetts, Department of Transportation (MassDOT), Formerly Massachusetts Highway Department (MHD) Standard Specifications for Highways and Bridges, latest edition, hereinafter referred to as the "Standard Specifications". All references to method of measurement, basis of payment, and payment items in the "Standard Specifications" are hereby deleted. References made to particular sections or paragraphs in the "Standard Specifications" shall include all related articles mentioned therein.
 6. MassDOT, Construction Standards, latest Edition with amendments, hereinafter referred to as the "Construction Standards."
 7. Commonwealth of Massachusetts State Plumbing Code, latest edition.
 8. Commonwealth of Massachusetts Regulations 528 CMR 12.00 Sprinkler Contractor Licensing Regulations.
 9. Town/City Water Department Regulations.

1.5 EXAMINATION OF SITE AND DOCUMENTS

- A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation of the site.
- B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.6 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of potable water systems materials and products, of types and sizes required, whose products have been in satisfactory use in similar service for not less than five years.
- B. Installer's Qualifications: Firm with at least three years of successful installation experience on projects with potable water piping work similar to that required for this project.
- C. Water Purveyor Compliance: Comply with requirements of Purveyor supplying water to project, obtain required permits and inspections.

1.7 PROJECT CONDITIONS

- A. Site Information: Perform site inspection and survey, research utility records, and verify existing utility locations and elevations. Verify that water system piping may be installed in compliance with Contract Drawings and referenced standards.
- B. Interruption of Existing Water Distribution System: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to the requirements indicated:
 - 1. Notify Architect no fewer than two days in advance of proposed interruption of service.
 - 2. Do not proceed with interruption of service without Architect's written permission.

1.8 SEQUENCING AND SCHEDULING

- A. Coordinate with interior building domestic water and fire protection system piping.
- B. Coordinate with other utility work.
- C. The Contractor is responsible for developing a sequence of work to maintain existing services in operation until the new services are operational.
- D. The Contractor is responsible for coordinating and scheduling the inspection of the work by the jurisdictional authority. All permits and inspection costs and fees shall be included in the bid prices and no additional costs will be paid to the Contractor.

PART 2-PRODUCTS

2.1 DUCTILE IRON PIPE AND FITTINGS

- A. General: Provide piping materials and factory fabricated piping products of sizes, types, pressure ratings, and capacities as indicated. Where not indicated, provide proper selection as determined by Engineer to comply with installation requirements. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.
 - 1. Ductile iron pipe shall be that of a manufacturer who can demonstrate at least five years of successful experience in manufacturing ductile iron pipe. The pipe shall be equipped with push on type, restrained joint, or mechanical joints, as required.
 - 2. All ductile iron water pipe shall conform to American Water Works Association (AWWA) C150 and AWWA C151.
 - 3. The ductile iron pipe shall be Class 52 and furnished in minimum nominal 18-foot lengths, with Push-on or Mechanical Joints as manufactured by U.S. Pipe and Foundry

- Company, Atlantic States Cast Iron Pipe Co., Clow Corporation, or approved equal with gaskets conforming to AWWA C111 "Rubber Gasket Joints". A minimum of two bronze wedges per joint shall be used to maintain conductivity and facilitate lock-on.
4. All ductile iron pipes shall be rated for a minimum operating pressure of 350 psi.
 5. The ductile iron water pipe shall be double cement lined inside and then asphalt seal coated in accordance with AWWA C104 and AWWA C151. The pipe shall be furnished along with necessary materials and equipment recommended by the manufacturer for use in joining pipe lengths and fittings.
 6. All water pipe shall be encased in polyethylene film when the trench is backfilled with control density fill.
 7. Fittings shall be ASTM A-536 ductile iron with mechanical joint fittings. All fittings 3 inches through 48 inches in diameter shall meet or exceed the requirements of AWWA C110. Compact fittings shall be ductile iron meeting or exceeding the requirements of AWWA C153. Fittings shall have the same lining and coating as the pipe specified above. All fittings shall be marked with the weight and shall have distinctly cast upon them the pressure rating, the manufacturer's identification, nominal diameter of openings and the number of degrees or fraction of the circle on all bends. All fittings 4 through 24 inches shall be Class 350. All fittings greater than 24 inches shall be as specified above except they shall be Class 250. Compact fittings shall only be used in sizes 4 through 24 inches. Fittings shall conform to the weights, excluding accessories, and dimension shown in the latest edition of the Handbook of Ductile Iron Pipe and come complete with all joint accessories as required. All accessories (gland, gaskets, T-bolts, and nuts) shall be in accordance with AWWA C111. All mechanical joint bolts (T-bolts) shall be Cor-Ten or equal.
 8. In order to provide positive joint restraint, valve anchor tees/valves and restrained joints shall be used on fire services and on the 6-inch branch connections for hydrants.
 9. Caps and plugs installed in all new work as indicated on the Contract Drawings shall be provided with a threaded corporation or bleeder valve so that air and water pressure can be relieved prior to future connection.
 10. Contractor shall provide all adapters and fittings such as transition couplings, as determined in the field, necessary to complete all cross connections, whether or not specifically stated in the Contract Drawings and Specifications.
 11. All pipe shall be marked with the class, thickness designation, and initials of the manufacturer.
 12. If required the manufacturer shall supply the Engineer with certificates of compliance with these Specifications and certification that each piece of ductile iron pipe has been tested at the foundry with the Ball Impression Test, Ring Bending, or equal.
 13. Thrust blocks shall be used at all bends and fittings as shown on the details. In addition, all bends and fittings shall be restrained with Megalug Series 1100 mechanical joint restraint. In the event that the use of thrust blocks is not practical or allowed, the Contractor shall provide an alternate method of joint restraint, at no additional cost to the owner, as approved and/or as directed by the Engineer. Restraint length calculations and restrained joint locations shall be provided by the contractor and submitted to the engineer for review. Restraint length values shall be calculated per the manufacturer's standards.
 - a. Restraint for standardized mechanical joints shall be incorporated in the design of the follower gland and shall impart multiple wedging action against the pipe, increasing its resistance as the pressure increases. The assembled joint shall maintain its flexibility after burial and shall maintain its integrity by a controlled and limited expansion of each joint during the wedging action. Restraining glands shall

be manufactured of high strength ductile iron conforming to the requirements of ASTM A536, Grade 65-45-12. Wedging mechanisms shall be manufactured of ductile iron, heat treated to a hardness of 370 BHN minimum. Dimensions of the gland shall be such that it can be used with the standardized mechanical joint bell and tee head bolts conforming to the requirements of ANSI/AWWA A21.11/C111 and ANSI/AWWA A21.53/C153 of latest revision. Twist-off nuts shall be incorporated in the design of the wedge activation screws to ensure proper torque. The mechanical joint restraining device shall have a water working pressure rating of 350 psi minimum (in sizes 4" thru 16") with a safety factor of at least 2:1 against separation when tested in a dead-end situation.

- b. Restraint for push-on ductile iron pipe shall consist of a wedge action restraint ring on the spigot joined to a split ductile iron ring behind the bell. The restraint ring shall have individually actuated wedges that increase their resistance to pull-out as pressure or external forces increase. The restraint ring and its wedging components shall be made of minimum grade 65-45-12 ductile iron conforming to ASTM A536. The wedges shall be heat treated to a minimum hardness of 370 BHN. Torque limiting twist off nuts shall be used to ensure proper actuation of the restraining wedges. The split ring shall be made of a minimum grade of 65-45-12 ductile iron conforming to ASTM A536. The connecting tie rods that join the two rings shall be made of low alloy steel that conforms to ANSI/AWWA C111/A21.11. The assembly shall have a rated pressure with a minimum two to one safety factor of 350 PSI in the sixteen-inch size and below 250 PSI in the eighteen through thirty-six-inch sizes. Push on joints on ductile iron pipe shall be restrained with Megalug Series 1700 restraint harness.
14. Insulation shall be manufactured by Thermal Pipe Systems, Atlas Insulation, or Insulated Piping Systems Inc., or other approved manufacturer. Insulation shall be factory foamed-in-place polyurethane foam insulation having nominal thickness of 1 1/2-inch, with an in-place density of 2.5 pcf, and a "K" factor of 0.16 BTU*in./hr.*°F*sq. ft. Straight joints between insulated pipe lengths, and the end sections of non-insulated pipe shall be sealed with heat shrinkable wrap-around polyethylene as supplied by manufacturer and installed in field by Contractor. Insulation jacket shall be 20-gauge corrugated aluminum preformed to be fastened with stainless steel screws and bands. Jacket shall have one layer of one mil polyethylene film with a protective coat of 40-pound virgin Kraft paper to act as a moisture and galvanic corrosion barrier.
15. Pipe for use with split couplings shall be as specified except that the ends shall not have bells or beads but shall have cast or machined shoulders or grooves as necessary for the couplings to be used and shall conform to the specifications of the manufacturer of the couplings. If split couplings are used with grooved ductile-iron pipe, the minimum pipe wall thickness shall be as follows:

Nominal Pipe Size (In.)	Thickness Class
4-12	53
14-18	54
20	55
24	56

16. Pipe for use with sleeve-type couplings shall be as specified except that the ends shall be plain (without bells or beads). The ends shall be cast or machined at right angles to the axis.

B. COUPLINGS AND ADAPTERS FOR DUCTILE IRON PIPE

1. Sleeve type couplings for plain end pipe shall be provided with plain rubber gaskets and steel, tee head bolts with nuts. Couplings shall be Dresser style 38 or 138, furnished preassembled, as manufactured by Dresser Industries, Inc., Smith Blair, Coupling Systems, Inc., or equal.
2. Couplings or adapters as required for connecting existing pipe to new pipe or new pipe to new pipe shall be furnished as required and designed for compatibility with the pipe and operating pressures encountered. Couplings shall be Dresser Style 162 as manufactured by Dresser Industries Inc., or equal. Flanged adapters shall be Dresser Style 128, or equal. Couplings for ductile iron to cast iron pipe shall be Style 53, and for ductile iron to transite pipe shall be style 153, as manufactured by Dresser Industries, Inc., or as manufactured by Smith Blair, Coupling Systems, Inc. or equal. Transition couplings shall be Style 162 as manufactured by Dresser Industries, Inc. or approved equal.
3. Split couplings may be used for connecting gray cast iron or ductile iron. If split couplings are used with grooved ductile iron pipe, the minimum pipe wall thickness shall be as specified. Split couplings shall be made of malleable iron and shall be suitable for use with grooved-end or shouldered-end, cast iron pipe. They shall be Victaulic couplings made by the Victaulic Company of America, Elizabeth, New Jersey; Gruzagrip couplings made by Gustin-Bacon Manufacturing Company, Kansas City, Missouri; Groove couplings made by Eastern Malleable Iron Company, Pittsburgh, Pennsylvania; or equal products.
4. Flexible Couplings: Sleeve type couplings for plain end ductile iron pipe shall be provided with plain rubber gaskets and steel, track head bolts with nuts.
5. Couplings shall be furnished pre-assembled by the manufacturer.
6. Couplings shall be given a shop coat compatible with the same outside coating as the pipe specified above.
7. All couplings shall be furnished with the pipe stop removed.
8. Couplings shall be provided with gaskets of a composition suitable for exposure to the liquid within the pipe. The gaskets shall have metallic tips to provide electrical continuity through the joint.
9. The Contractor shall provide suitable filling rings where the layout of the flanged piping is such as to necessitate their use. In materials, workmanship, facing, and drilling, such rings shall conform to the 125-pound ANSI Standard. Filling rings shall be of suitable length with nonparallel faces and corresponding drilling, if necessary, to ensure correct assembly of the adjoining piping or equipment.
10. Couplings for exposed pipe shall be of steel and shall be Dresser Style 38, Smith-Blair Style 411, Baker Allsteel, or equal. The couplings shall be provided with steel bolts and nuts.
11. At the Contractor's option, flexible connections in the piping shall be sleeve-type couplings, split couplings or mechanical joint pipe as herein specified.

C. INSPECTION, TESTS, AND ACCEPTANCE FOR DUCTILE IRON PIPE

1. All pipe delivered to the job site shall be accompanied by test reports certifying that the pipe and fittings conform to "AWWA Standard for Ductile Iron Pipe, for Water and Other Liquids" (AWWA H3) and (AWWA C151).
2. All tests shall be made in accordance with the methods prescribed by the above mentioned AWWA Standards, and the acceptance or rejection shall be based on the test results.
3. Pipe which does not conform to the requirements of this contract shall be immediately removed and replaced by the Contractor.

4. All ductile iron pipe to be installed under this Contract may be inspected at the foundry for compliance with these Specifications by an independent testing laboratory selected by the Owner. The Contractor shall require the manufacturer's cooperation in these inspections. The cost of foundry inspection of all pipe approved for this Contract, plus the cost of the inspection of a reasonable amount of disapproved pipe, will be borne by the Owner.

D. FLANGED JOINTS FOR DUCTILE IRON PIPE

1. For flanged joints, gaskets shall be ring gaskets of rubber with cloth insertion. Gaskets twelve (12)-inches in diameter and smaller shall be 1/16-inch thick, gaskets larger than twelve (12)-inch shall be 3/32-inch thick.
2. Flanged joints shall be made with bolts, bolt studs with a nut on each end, or studs with nuts where the flange is tapped. The number and size of bolts shall conform to the same ANSI Standard as the flanges. Bolts and nuts shall, except as otherwise specified or noted on the Contract Drawings, be Grade B conforming to the ASTM Standard Specification for Carbon Steel, Externally and Internally Threaded Standard Fasteners, Designation A307. Bolts and studs shall be of the same quality as machine bolts. Flanged ductile iron pipe from 3 to 48-inches in diameter shall be classified by Underwriters Laboratories Inc. in accordance with AWWA C115.

2.2 PVC WATER PIPE

- A. General: Provide pipes of the following materials of class indicated. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.
- B. PVC pipe used for water mains shall be polyvinyl chloride (PVC) pipe, Class 150 with integral thickened wall bells, as manufactured by Manville Corporation, Certain Teed Corporation, Capco or approved equal. Pipe shall be made from clean, virgin approved Class 12454 B PVC compound conforming to AWWA Specification C900.
- C. All pipe shall meet with cast iron pipe equivalent outside diameters.
- D. All pipe and fittings shall be marked with size, class, material, grade, and initials of the manufacturer. The pipe shall be furnished in standard 20-foot lengths.
- E. All pipes shall be suitable for use as a pressure conduit for potable water.
- F. Each pipe length shall be hydrostatic proof tested to four times the class pressure of the pipe for a minimum of five seconds.
- G. The pipe shall withstand without failure an impact of 100 ft./lb. for pipe sizes 8 inches and smaller from a freely falling missile; with a 2-inch radius nose at 70°F., as per ASTM D2444. There shall be no visible evidence of shattering, cracking or splitting when energy is imposed.
- H. Randomly selected samples shall be quick burst tested in accordance with ASTM D1599. The pipe shall withstand without failure a pressure of 755 psi applied in 60 to 70 seconds at 73°F.
- I. The pipe shall not balloon, burst or weep as defined in ASTM D1598 when tested at a sustained pressure of 500 psi applied for 1,000 hours as specified in ASTM D2241.

- J. The inside surface of each length of pipe shall be free from nicks, scratches and other surface defects and blemishes. The pipe shall be homogeneous throughout free of any bubbles, voids or inclusions.
- K. If requested, the manufacturer shall supply the Engineer with certificates of compliance with specifications and certifications that each piece of PVC pipe conforms to AWWA Specification C900 and has been tested with the Drop Impact Test in accordance with ASTM D2444.
- L. The integral socket bell of the PVC pipe shall meet the same strength requirements as that of the pipe. The bell shall have grooves into which an elastomeric gasket with solid cross section is inserted. This joint shall conform to the requirements of ASTM D3139 and shall provide for expansion and contraction of the pipe.
- M. Removable elastomeric gaskets for PVC pipe and fittings shall meet the requirements of ASTM F477 and shall be capable of withstanding pH's as high as 9.5. The elastomeric gasket shall provide a tight seal that protects the line from shock and vibration, and compensates for expansion and contraction of pipe lengths. The elastomeric gasket shall not support the growth of bacteria.
- N. Lubricant used for joint assembly shall be non-toxic, shall not support the growth of bacteria and shall have no deteriorating effect on the gasket material.
- O. Restrained joints shall be furnished for installation where shown on the Contract Drawings. Restraints for mechanical joint fittings shall be Series 1100 PV Megalug as manufactured by EBAA Iron Sales Co. or approved equal. Restraints for push-on joints shall be Series 2000PV as manufactured by EBAA Iron Sales Co. or approved equal.

2.3 RESILIENT WEDGE GATE VALVES

- A. Resilient wedge gate valves shall be iron body, resilient seated type. The valves shall be designed for 250 psi working pressure and 400 psi test pressure.
- B. Valves are to have O ring seals and a nonrising stem. Valves shall have a 2-inch operating nut. Valves shall open in the Town of Wakefield standard direction.
- C. Resilient gate valves shall meet the most recent version of the AWWA standard specification AWWA C509.
- D. Resilient wedge valves shall have mechanical joint ends.
- E. Valves shall be as manufactured by U.S. Pipe and Foundry Company Metroseal 250, American Flow Control Model AFC2500, or Mueller Resilient Wedge Gate Valves.
- F. Valve boxes shall be cast iron, asphalt coated, sliding, heavy pattern type, consisting of three (3) pieces; a flanged bottom piece, a flanged top piece, and a cover with two (2) lifting holes and the word "water" cast on the top. A minimum 6-inch overlap is required between sliding sections. The valve box shall be designed and constructed to prevent direct transmission of traffic loads to the pipe or valve. The inside diameter of boxes shall be at least 4 1/2 inches and lengths shall be as necessary to suit ground elevation. The top of the cover shall be flush with the top of the box rim. Box covers shall be round frame and cover.
- G. Valves shall be connected directly to valve anchor tees at all hydrant branches.

2.4 TAPPING SLEEVES AND VALVES

- A. Tapping sleeves shall be of ductile iron construction, meeting ASTM A536 Grade 65-45-12. Side flange seals shall be O-Ring type of round, oval or rectangular cross-section shape. Sizes 12" and smaller must be capable of working on Class ABCD pipe diameters without changing either half of sleeve. Sizes 14" and larger must be specified to which class is needed. All sleeves are to include the end joint accessories and split glands necessary to assemble sleeve to pipe. Sleeve shall be coated with asphaltic varnish in compliance with NSF-61.
- B. Tapping valves shall conform to the requirements specified above for gate valves except that all Tapping sleeves and valves shall consist of a ductile iron flanged by mechanical joint sleeves and a tapping type gate valve with one flange and one mechanical joint end. The Contractor shall be responsible for verifying the outside diameter of the pipe to be tapped.
- C. The valve shall be provided with an oversized seat to permit the use of full-size cutters. Before backfilling, all exposed portions of any bolts used to hold the two halves of the sleeves together shall be heavily coated with two coats of bituminous paint comparable to Inertol No. 66 Special Heavy. Sleeves shall be of ductile iron furnished with O-ring gaskets.
- D. Bolts on bonnet and stuffing box shall be stainless steel (316 stainless steel), stuffing boxes shall be "O" ring type as indicated. Gaskets shall cover the entire flange surface.

2.5 HYDRANTS

- A. General: Provide Hydrants as indicated. The Hydrants shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the hydrant.
 - 1. Fire hydrants shall meet or exceed AWWA C-502, latest revision and shall comply with Factory Mutual Research Corporation and Underwriters' Laboratories UL 246 Standard. Rated water working pressure shall be 200 psi, test pressure shall be 400 psi.
 - 2. The main valve closure shall be of the compression type, opening against the pressure and closing with the pressure.
 - 3. Hydrants shall be of the breakaway type: The upper barrel shall connect to the lower barrel with a breakable traffic flange and 8 bolts and nuts. This connection shall allow 360° rotation of the upper nozzle section.
 - 4. The main valve opening shall be 5-1/4 inch and be designed so that removal of seat, drain valve mechanism, internal rod and all working parts can be removed through top of hydrant. These parts shall be removable without disturbing the ground line joint or the nozzle section of the hydrant. The bronze seat shall be threaded into mating threads of bronze for easy field removal.
 - 5. The draining system of the hydrant shall be bronze and activated by the main stem without use of auxiliary rod, toggles, pins, etc. The drain mechanism shall be completely closed after no more than three turns of the operating nut in the opening direction. There should be a minimum of (2) inside ports and (4) drain port outlets to the exterior of the hydrant. Drain shut off to be by direct compression closure.
 - 6. The operating nut, main stem, coupling and main valve assembly shall be capable of withstanding input torque of 200 ft. lbs. in opening or closing directions. There shall be an internal top housing with triple O-Rings to seal operating threads from the waterway and accommodate an anti-friction washer.
 - 7. Fire hydrants shall have 6-inch mechanical joint inlet connections to the main, two 2 1/2-inch hose connections, 180-degrees apart, and one 4 1/2-inch steamer connection. The

hose and steamer connections shall have National Standard Thread. The standpipe shall have an 8 ½-inch minimum diameter. All nozzle caps shall be cast iron and shall be secured to the hydrant barrel with chains.

8. Hydrant shall be marked with an arrow and the word "open" to indicate the direction to turn the stem to open the hydrant. Hydrants shall open in the Town of Wakefield standard direction and have a bronze operating nut that shall be pentagonal in shape, 1-1/2 inch from point to opposite flat.
9. The upper barrel shall be ductile iron with markings identifying size, model and year of manufacture. The lower barrel shall be ductile iron.
10. The hydrant shall have a minimum working pressure of 200 psi. Hydrant design shall be of positive automatic drain type to prevent freezing.
11. Hydrants shall be thoroughly cleaned and given two (2) shop or field coats of paint in accordance with AWWA C502 and the instruction of the paint manufacturer. Paint color shall be the standard hydrant color of the Town of Wakefield.
12. If the hydrant is delivered with the manufacturer's standard color, the hydrant shall be given one (1) matching field coat of alkyd gloss enamel. If the hydrant is delivered with no standard color, the hydrant shall be given two (2) coats of alkyd gloss enamel according to the colors specified by the Town of Wakefield.
13. All exposed metal surfaces will be painted.
14. Hydrant paint shall be as manufactured by Sherman-Williams, PPG Industries, Pittsburgh, PA; Koppers Company, Inc., Pittsburgh, PA; Tnemec Company, Inc. Kansas City, MO; or approved equal.
15. Alkyd gloss enamel shall be Series 54-300 by PPG; Glamortex by Koppers; 2H-Tneme by Tnemec or approved equal.
16. Hydrants shall be American Darling (American Flow Control) Model B-62 B, Mueller Centurion, Kennedy Guardian, U. S. Pipe Metropolitan, Waterous WB-67 or others as acceptable to the jurisdictional authority.

B. HYDRANT SAFETY FLANGE REPAIR KIT

1. Safety flange repair kits shall come complete with stem coupling, safety flange, flange gasket, replacement bolts and nuts and hydrant lubricating oil.
2. Safety flange repair kits shall be compatible with hydrant furnished.

C. HYDRANT EXTENSION KITS

1. Extension kits shall come complete with extension barrel, extension stem, stem coupling and hardware, flange, flange gasket, 8 bolts and nuts and hydrant lubricating oil.
2. Extension kits shall be compatible with hydrant furnished.

2.6 SERVICE TUBING, CORPORATIONS, STOPS, SADDLES, AND VALVE BOXES

- A. Service tubing shall meet the requirements of Federal Specification WW-T 7996 and shall conform to ASTM specification B75, B68 and B88 as they apply to Type K Copper Tubing.
- B. Copper Tube Size (CTS) Polyethylene Tubing for domestic water uses shall conform to AWWA C901, ASTM D3350, and ASTM D2737 and shall have a working pressure rating of 200 psi. Tracer wire shall be attached to the tubing and connected to upstream piping of the associated water meter for the water service, as applicable.

- C. The Contractor shall furnish and install, including necessary taps and connections, corporation stops, CTS Polyethylene Tubing, curb stops and wastes.
- D. The corporation stops shall meet the most recent revision of the AWWA standard "Threads for Underground Service Line Fittings." (AWWA C800).
- E. Corporation stops shall be sized as shown on the drawings and be brass compression-type with CC thread (Mueller Brand with compression nut with set screw). Corporation stops shall open in the standard direction of the Town of Wakefield.
- F. Curb Stops: Curb stops shall be sized as shown on the drawings and be brass compression-type with drain (Mueller Brand with compression nut with set screw). Curb stops shall open in the standard direction of the Town of Wakefield.
- G. Tapping Saddles: Service connections shall be tapped with Size 2" X 8" double strap service saddles.
- H. Fittings and Boxes: Service boxes shall be cast iron. Extension service boxes of the required length and having slide-type adjustment shall be installed at all service box locations. The boxes shall have housings of sufficient size to completely cover the curb stop and shall be complete with identifying covers
- I. Service boxes shall be 2 ½" Buffalo Style, heavy cast iron, tar coated, sliding type, consisting of three (3) pieces; a flanged bottom piece, a flanged top piece and bolted cover with the word "water" cast on the top. A minimum 6-inch overlap is required between sliding sections. The boxes lengths shall be as necessary to suit ground elevation.

2.7 IDENTIFICATION

- A. Detectable Underground Warning Tapes: Acid and alkali-resistant polyethylene plastic film warning tape, 6-inches wide by 4-mils. minimum thickness, with continuously printed caption in black letters "CAUTION - xxxxx LINE BURIED BELOW." The text and color of the tape shall be as shown in the table below. The tape shall have a metallic core encased in a protective jacket for corrosion protection and be detectable by a metal detector when the tape is buried up to 2.5-feet deep.

Color	Utility
Safety Red	Electric
High Visibility Safety Yellow	Gas, Oil, Steam
Safety Alert Orange	Telephone, Communications, Cable Television
Safety Precaution Blue	Water System, Irrigation
Safety Green	Sanitary Sewer, Storm Sewer

PART 3-EXECUTION

3.1 INSPECTION

- A. General: Examine areas and conditions under which potable water system's materials and products are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Engineer.

- B. The Contractor is responsible for the provisions and all test requirements specified in herein. In addition, all pipe and appurtenances may be inspected at the plant for compliance with these specifications by an independent testing laboratory.
- C. All tests shall be made in accordance with the methods prescribed by the above-mentioned AWWA Standards, and the acceptance or rejection shall be based on the test results.
- D. Inspection of the pipe and appurtenances may also be made after delivery. The pipe and appurtenances shall be subject to rejections at any time on account of failure to meet any of the specifications requirements, even though samples may have been accepted as satisfactory at the place of manufacture.
- E. Pipe which does not conform to the requirements of this contract shall be immediately removed and replaced by the Contractor at no cost to the Owner.

3.2 HANDLING PIPE

- A. The Contractor shall take care not to damage pipe by impact, bending, compression, or abrasion during handling, and installation. Joint ends of pipe especially shall be kept clean.
- B. Pipe shall be stored above ground at a height no greater than 5-feet, and with even support for the pipe barrel.
- C. Only nylon protected slings shall be used for handling the pipe. No hooks, chains or bare cables will be permitted.
- D. Gaskets shall be shipped in cartons and stored in a clean area, away from grease, oil, heat, direct sunlight and ozone producing electric motors.

3.3 INSTALLATION OF PIPE AND PIPE FITTINGS

- A. The Contractor shall provide all adapters and fittings such as transition couplings, as determined in the field, necessary to complete all cross connections, whether or not specifically stated in the Contract Drawings and Specifications.
- B. Care shall be taken in loading, transportation, and unloading to prevent injury to the pipe or coatings. Pipe or fittings shall not be dropped. All pipe and fittings shall be examined before placement, and no piece shall be installed which is found to be defective. Any damage to the pipe coatings shall be repaired as directed by the Engineer or Owner's Representative.
- C. If any defective pipe is discovered after it has been placed, it shall be removed and replaced with a sound pipe in a satisfactory manner by the Contractor, at his own expense. All pipe and fittings shall be kept clean until they are used in the work, be thoroughly cleaned before placement, and when placed, shall conform to the lines and grades required. Ductile iron pipe and fittings shall be installed in accordance with requirements of AWWA Standard Specification C600 except as otherwise provided herein. A firm even bearing throughout the length of the pipe shall be constructed by compacting sand gravel borrow around the pipe and up to 18 inches above the pipe.
- D. Blocking will not be permitted.
- E. A minimum horizontal separation of ten (10) feet shall be maintained between and existing, proposed or relocated sewer and the new water main. The distance shall be measured edge to edge. In cases where it is not practical to maintain a ten-foot separation, it is permitted to install a water main closer to a sewer, provided that the water main is laid in a separate trench or on an undisturbed earth shelf located eighteen (18) inches above the top of sewer. Where

the horizontal clearance is less than ten (10) feet or the vertical clearance is less than eighteen (18) inches and the sewer crosses under the water main, both water main and sewer main shall be constructed of mechanical joint cement lined ductile iron pipe for 10-feet on either side of the crossing. One (1) full length of water pipe shall be centered over the sewer at the crossing. If the sewer crosses over the water main, regardless of the vertical separation, both pipes shall be concrete encased for a distance of ten (10) feet to either side of the respective centerline.

- F. Provide minimum cover over piping of 5-feet below finished grade.
- G. Extend water systems from the water main located within the public way and terminate potable water piping 10-feet 0-inches from the building foundation. Provide temporary pipe plug for piping extension into building if required by construction progress.
- H. All pipes shall be sound and clean before placement. When pipe laying is not in progress, including lunchtime, the open ends of the pipe shall be temporarily closed by watertight plug or other acceptable means. Alignment shall be maintained during placement. The deflection at joints shall not exceed sixty percent of that recommended by the manufacturer. Fittings, in addition to those shown on the plans, shall be provided, if required, in crossing utilities, which may be encountered upon opening the trench. Solid sleeves shall be used only where allowed by the Engineer.
- I. When cutting pipe is required, the cutting shall be done by machine, leaving a smooth cut at right angles to the axis of the pipe. Cut ends of pipe to be used with a push-on type bell shall be beveled to conform to the manufactured spigot end. Cement lining shall be inspected for damage and shall be re-mortared as required to ensure a continuous lining.
- J. Mechanical joint restraints shall be used for all valves, bends, hydrants and piping section less than 50 feet. The contractor shall restrain all pipe runs to the lengths indicated on the approved restrained joint calculation shop drawings.
- K. Jointing of ductile iron push on pipe and fittings shall be done in accordance with the printed recommendations of the manufacturer and as specified. The last 8 inches of the outside of the spigot end of pipe and the inside of the bell end of pipe shall be thoroughly cleaned. The joint surfaces and the gasket shall be painted with a lubricant just prior to making up the joint. The spigot end shall then be gently pushed home into the bell. The position of the gasket shall be checked to ensure that the joint has been properly made and is watertight. Care shall be taken not to exceed the manufacturer's recommended maximum deflection allowed for each joint.
 - 1. Jointing Ductile Iron Pipe (Push-On Type): Push-on joints shall be made in strict accordance with the manufacturer's instructions. Pipe shall be laid with bell ends looking ahead. A rubber gasket shall be inserted in the groove of the bell end of the pipe, and the joint surfaces cleaned and lubricated. The plain end of the pipe to be entered shall then be inserted in alignment with the bell of the pipe to which it is to be joined, and pushed home with a jack or by other means. After joining the pipe, a metal feeler shall be used to make certain that the rubber gasket is correctly located.
 - 2. Jointing Mechanical Joint Fittings: Mechanical joints at valves, fittings, and where designated shall be installed in accordance with the "Notes on Method of Installation" under ANSI Specification A 21.11 and the instructions of the manufacturer. To assemble the joints in the field, the Contractor shall thoroughly clean the joint surfaces and rubber gasket with soapy water before tightening the bolts. Bolts shall be tight to the specified torque. Under no condition shall extension wrenches or pipes over handles or ordinary ratchet wrenches be used to secure greater leverage.

- L. Installation and jointing of ductile iron pipe shall be in accordance with AWWA C600, Sections 9b and 9c, latest revision, as applicable.
- M. Service tubing shall be installed with minimum 6-inches of sand bedding and 12-inches sand cover. Service tubing shall have a minimum total cover of 5 feet.

3.4 INSTALLATION OF VALVES AND APPURTENANCES

- A. Cleaning and Prime Coating Valves and Appurtenances (Except Epoxy Coated Valves)
 - 1. Prior to shop prime coating, all surfaces of the valves and appurtenances shall be thoroughly clean, dry, and free from all mill-scale, rust, grease, dirt, paint and other foreign substances to the satisfaction of the Engineer or Owner's Representative.
 - 2. All ferrous surfaces shall be sand blasted or pickled according to SSPC-SP6 or SSPC-SP8, respectively.
 - 3. All gears, bearing surfaces and other surfaces not to be painted shall be given a heavy coat of grease or other suitable rust resistant coating unless otherwise specified herein. This coating shall be maintained as required to prevent corrosion during any period of storage and installation and shall be satisfactory through the time of final acceptance.
- B. Installation
 - 1. All valves and appurtenances shall be installed in the location shown, true to alignment and rigidly supported. Any damage to the above items shall be repaired before they are installed.
 - 2. Care shall be taken to prevent damage to valves and appurtenances during handling and installation. All materials shall be carefully inspected for defects in workmanship and materials, all debris and foreign material cleaned out of valve openings, etc., and all operating mechanisms operated to check their proper functioning, and all nuts and bolts checked for tightness. Valves and other equipment that does not operate easily, or are otherwise defective, shall be repaired or replaced.
- C. Shop Painting Valves and Appurtenances
 - 1. Interior and exterior surfaces of all valves which are not factory epoxy coated shall be given two coats of shop finish of an asphalt varnish conforming to AWWA C504 for Varnish Asphalt. The pipe connection openings shall be capped to prevent the entry of foreign matter prior to installation.
- D. Buried Valves
 - 1. Install valves as indicated with stems pointing up. Provide valve box over underground valves. Buried valves and boxes shall be set with the operating stem vertically aligned in the center of the valve box. Valves shall be set on a firm foundation and supported by tamping selected excavated material under and at the sides of the valve.
- E. Valve Boxes
 - 1. Valve boxes shall be installed vertically, centered over the operating nut, and if they are within the limits of the roadway or within limits where the plowing of snow will take place in the winter, the tops of the boxes shall be set $\frac{1}{2}$ " below the top of the finished grade. In locations where these boxes are not likely to be disturbed, the tops shall be set flush with the adjoining ground. Boxes shall be adequately supported during backfilling to maintain vertical alignment.
- F. Corporation Cocks

1. The tapping machine shall be rigidly fastened to the pipe as near the horizontal diameter as possible. The length of travel of the tap should be so established that when the stop is inserted and tightened with at 14" wrench, not more than one to three threads will be exposed on the outside. When a wet tapping machine is used, the corporation stop shall be inserted and tightened in accordance with the manufacturer's specifications.

3.5 INSTALLATION OF HYDRANTS

- A. Hydrants and hydrant branches shall be tested at 175 psi and chlorinated as specified in this specification.
- B. Hydrants shall be installed in conformance to AWWA C 600, Section 11, latest revision, using thrust blocks and restrained joints in accordance with the details shown on the Contract Drawings.
- C. Hydrants, as detailed on the Contract Drawings, shall be set at the locations designated by the Engineer and shall be bedded on a firm foundation. A drainage pit 2-feet 6-inches in diameter and to the limits shown on the Contract Drawings shall be filled with crushed stone and satisfactorily compacted. During backfilling, additional crushed stone shall be brought up around, and 6-inch over the drain port. Each hydrant shall be set in true vertical alignment and shall be properly braced. Thrust blocks shall be placed between the back of the hydrant inlet and undisturbed soil at the end of the trench. Hydrant shall be set upon a slab of concrete not less than 4-in thick and 15-in square.
- D. Hydrants shall be set plumb with the steamer nozzle facing the roadway and the center of the operating nut located 18-inches back from the face of curb or edge of pavement.
- E. Hydrants shall be set such that the bottom of the breakaway feature shall be a minimum of 2-inches and a maximum of 4-inches above finish grade.
- F. Once installed, hydrants shall be painted once again by the Contractor. Hydrants shall be painted in accordance with the Owner's requirements.
- G. All iron work to be set below ground, after being thoroughly cleaned, shall be painted with two coats of asphalt varnish as specified in AWWA C502, latest revision and iron work to be left above ground shall be shop painted with two coats of paint.
- H. Thrust Blocks: Concrete thrust blocks shall be placed between the back of the hydrant inlet and undisturbed soil at the end of the trench. Minimum bearing area shall be as shown on the Contract Drawings. Felt paper shall be placed as shown on the Contract Drawings. Care must be taken to ensure that concrete does not plug the drain ports.

3.6 BACKFILLING

- A. General: Conduct excavation and backfill operations for utility installations in accordance with Section 312000 – EARTH MOVING/Section, local requirements, and the contract documents.
- B. Initial backfill shall be placed evenly on both sides of the pipe to distribute the load and not to cause movement or deflection of the pipe.

3.7 FIELD QUALITY CONTROL

- A. Testing of Water Main/Service:

1. Prior to pressure testing, the entire line shall be water jetted to remove any rocks or debris that may have inadvertently entered the pipe during construction.
2. The Contractor in accordance with AWWA C651-99 specifications or latest revision will make pressure and leakage tests thereof, to determine that the ductile iron pipe is structurally safe and free of excess leakage. Pipeline shall be subject to a hydrostatic test of 150 pounds per square inch (psi) or 150% of the static pressure, whichever is greater. The Contractor shall furnish all equipment, materials, and labor for testing. Testing shall be done between valved off sections in approximately 1000-foot maximum section of the main. The Contractor shall furnish at his own expense the water needed for all water main testing.
3. Once the pipeline section has been filled at normal pressure and all entrapped air removed from the line, the Contractor shall raise the pressure to the approved test pressure by a special pressure pump taking water from a small tank of proper dimensions for satisfactorily measuring the rate of pumpage into the pipeline. The pipe shall maintain this pressure, within 5 psi, for a minimum of two hours during which time the line shall be checked for leaks. The measured water leakage shall not exceed the maximum allowed leakage as determined by the following equation for the section under test:

$$L = SDP^{1/2} / (133,200)$$

Where:

L = Allowable leakage, gallons per hour

S = Length of pipe section tested, feet
(1,000-foot maximum)

D = Nominal pipe diameter, inches.

P = Average test pressure (psi)

Should leakage exceed this rate, the Contractor shall immediately locate the leak or leaks and repair same at his expense. Pipe shall be flushed and chlorinated when leakage does not exceed above standard. Approval does not absolve the Contractor from his responsibility if leaks develop within the new main or water services (to curb box) later within the period of warranty.

B. Testing of Fire Protection Service:

1. Testing of fire protection services shall conform to the most current NFPA requirements.

C. Chlorinating and Flushing:

1. Prior to chlorination, the Contractor shall properly flush mains. In general, flushing shall be performed at a flow rate required to achieve a minimum velocity of 2.5-feet per second (approximately 900 GPM in a 12-inch diameter main and 400 GPM in 8-inch diameter main). Flushing shall be performed for a sufficient period of time to allow for a minimum of 3 volume changes of water in the main (approximately 20 minutes per 1,000-foot of 8-inch main at the above flow rate).
2. Chlorinating shall be accomplished by pumping a chlorine solution into the mains. Water shall be allowed to enter the new water mains until the mains are full of a solution containing 25-ppm available chlorine. The valves shall then be closed and the chlorinated water allowed to stay in the mains for 24 hours. At the end of this period, the chlorine residual shall be at least 10 mg/l. If it is less than 10 mg/l measured, Contractor shall flush and rechlorinate the mains at no cost to the Owner. All valves and hydrants shall be operated to ensure their proper disinfection and shall be manipulated to prevent superchlorinated water from entering the existing distribution system. After

- this period, the Contractor shall flush the mains until clear, clean water is being discharged.
3. Chlorinating and flushing shall be done in accordance with AWWA C651-99 Specifications.
 4. Twenty-four hours after the main has been flushed of chlorinated water, bacteriological samples shall be taken. Water samples shall be taken from corporation stops along the length of the water main. A minimum of two (2) samples shall be taken, per 3,000 foot of pipe or on each street, whichever is greater, each in duplicate, in sterile bottles and sent to a State approved private laboratory for analyses. The Contractor shall perform all necessary work including delivery of samples to a certified laboratory, and shall include the cost of sampling and analysis in his bid price. The results of the tests on these samples will determine the acceptance of the work and allow these new mains to be connected to the District's system. The failure of any sample to pass the laboratory tests shall require the Contractor to reflush and rechlorinate the mains and resample and test the water until acceptable results are obtained, all at no additional cost to the Owner.
 5. The Contractor shall submit a Disinfection report detailing the following:
 - a. Type and form of disinfectant used.
 - b. Date and time of disinfectant injection start and time of completion.
 - c. Test locations.
 - d. Initial and 24-hour disinfectant residuals (quantity in treated water) in ppm for each outlet tested.
 - e. Date and time of flushing start and completion.
 - f. Disinfectant residual after flushing in ppm for each outlet tested.
 6. The Contractor shall submit a Bacteriological Report detailing the following:
 - a. Date issued, project name, and testing laboratory name, address, and telephone number.
 - b. Time and date of water sample collection.
 - c. Name of person collecting samples.
 - d. Test locations.
 - e. Initial and 24-hour disinfectant residuals in ppm for each outlet tested.
 - f. Coliform bacteria test results for each outlet tested.
 - g. Certification that water conforms, or fails to conform, to bacterial standards.
 7. Contractor shall note that work under this Contract shall NOT be considered completed until satisfactory installation and testing of the water mains have been completed.

3.8 FINAL INSPECTION

- A. Final inspection and acceptance of pipe, valves, appurtenances, and hydrants shall be made by the Owner's Representative and the utility owner having jurisdiction of the particular system. Prior to placing the systems in service, all components shall be inspected, with the Owner's Representative present, to ensure that no debris or other contaminants are present. If necessary, the Contractor shall clean and flush piping.
- B. The Contractor is responsible for coordinating and scheduling the inspection of the work by local jurisdictional authorities. No additional payment will be made for inspections and permits required in the performance of the work.

END OF SECTION 331000

SECTION 333000
SANITARY SEWERAGE UTILITIES

PART 1-GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all SECTIONS within DIVISION 1 – GENERAL REQUIREMENTS, which are hereby made a part of this Section of Specifications.

1.2 DESCRIPTION OF WORK

- A. Work Included: Provide labor, materials, and equipment necessary to construct the sanitary sewer system complete, including connection to existing structures and testing, as indicated on the Drawings and as specified.
- B. Unless otherwise indicated on the Drawings, building sewer service lines shall be installed from a point 10 feet outside the building foundation walls to the point of disposal.
- C. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
 - 1. Section 311000 – SITE CLEARING for site clearing, removal of trees, stumps and other vegetation, topsoil stripping, stockpiling, clearing and grubbing, and removal of site surface and utility improvements.
 - 2. Section 312000 – EARTH MOVING for excavation, backfill, and compaction required for sanitary sewerage system piping and structures.
 - 3. Section 333600 – UTILITY SEPTIC TANKS for septic system requirements.
 - 4. Section 221316 – SANITARY WASTE AND VENT PIPING for building sanitary drain and vent requirements.

1.3 SUBMITTALS

- A. Refer to Section 013300 – SUBMITTAL PROCEDURES, for submitted provisions and procedures.
 - 1. Product Data: Submit manufacturer's technical product data and installation instructions for sanitary sewer system materials and products.
 - 2. Submit descriptive literature for piping, fittings, couplings, and appurtenances showing dimensions, pipe and joint materials, and other details for each class or type of pipe or product to be furnished for this contract. All pipe furnished under the contract shall be manufactured in accordance with these Specifications.
 - 3. Shop Drawings: The precast concrete structure shop drawing submittals for the manholes, septic tanks, dosing chambers, tight tanks, grease traps, wet wells, and valve pits shall contain erections drawings showing connections, cast-in items, waterproofing details, lifting hooks, and productions drawings showing elevations, sections, and details indicating sizes and quantities of reinforcement.
 - 4. Submit shop drawings for structure hatches and frames and covers.
 - 5. The Contractor shall submit buoyancy calculations for sanitary sewerage structures assuming groundwater is one (1) foot below finish grade. If buoyancy is an issue the structure(s) shall be modified to prevent uplift. All buoyancy calculations and precast

concrete structure designs shall be prepared and stamped by a professional Civil Engineer licensed in the Commonwealth of Massachusetts.

6. Material Certificates: Provide copies of material certificates signed by material producer and Contractor, certifying that each material item complies with, or exceeds specified requirements.
7. Prior to the acceptance of the sanitary sewerage system, the Contractor shall submit to the Engineer, for review and approval, As-Built Drawings that indicate the true measurement and location, horizontal and vertical, of all new construction. As-Built drawings shall be stamped and signed by a Massachusetts Licensed Land Surveyor or Licensed Professional Engineer. The as-built plans shall also be submitted electronically as an AutoCAD drawing file (release 2010 or higher).
8. Prior to the acceptance of the sanitary sewerage system, the Contractor shall submit the results of the leakage tests, pipe deflection measurements, and the video inspection reports.

1.4 REFERENCE STANDARDS

- A. The following standards are applicable to the work of this Section to the extent referenced herein:
 1. ASTM: American Society for Testing and Materials.
 2. ANSI: American National Standards Institute.
 3. Reference is made herein to the Commonwealth of Massachusetts, Department of Transportation (MassDOT), formerly Massachusetts Highway Department (MHD) Standard Specifications for Highways and Bridges, latest edition, hereinafter referred to as the "Standard Specifications". All references to method of measurement, basis of payment, and payment items in the "Standard Specifications" are hereby deleted. References made to particular sections or paragraphs in the "Standard Specifications" shall include all related articles mentioned therein.
 4. MassDOT Construction Standards, latest edition with amendments, hereinafter referred to as the "Construction Standards".
 5. Town/City Sewer Department Regulations.

1.5 EXAMINATION OF SITE AND DOCUMENTS

- A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation on the site.
- B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.6 QUALITY ASSURANCE

- A. Environmental Compliance: Comply with applicable portions of local environmental agency regulations pertaining to sanitary sewerage systems.
- B. Utility Compliance: Comply with the Town of Wakefield Sewer regulations, standards, and guidelines pertaining to sanitary sewerage system installation and inspections.

- C. Sanitary sewerage system installation shall be in conformance with the latest edition of TR-16, Guides for the Design of Wastewater Treatment Works.
- D. Plumbing Code Compliance: Comply with the applicable portions of the latest editions of the Massachusetts Plumbing Code and National Standard Plumbing Code pertaining to the selection and installation of sanitary sewerage system materials and products.
- E. Subsurface Disposal System Code Compliance: Comply with the applicable portions of the Commonwealth of Massachusetts State Environmental Code Title V, 310 CMR 15.00, latest revision and the local Board of Health Regulations pertaining to the installation of sanitary sewerage system materials and products.
- F. Manufacturer's Qualifications: Firms regularly engaged in manufacturing of sanitary sewer system products of type, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than five years.
- G. Installer's Qualifications: Firms with at least three years of successful installation experience on projects with sanitary sewer work similar to that required for the project.

1.7 PROJECT CONDITIONS

- A. Site Information: Perform site inspection and survey, research utility records, and verify existing utility locations and elevations. Verify that sewerage system structures and piping may be installed in compliance with Contract Drawings and referenced standards.
- B. Interruption of Existing Sanitary Sewer Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to the requirements indicated:
 - 1. Notify Architect no fewer than two days in advance of proposed interruption of service.
 - 2. Do not proceed with interruption of service without Architect's written permission.

1.8 SEQUENCING AND SCHEDULING

- A. Coordinate with interior building sanitary sewerage system piping.
- B. Coordinate with other utility work.
- C. The Contractor is responsible for developing a sequence of work to maintain existing services in operation until the new services are operational.
- D. The Contractor is responsible for coordinating and scheduling the inspection of the work by the jurisdictional authority. All permits and inspection costs and fees shall be included in the bid prices and no additional costs will be paid to the Contractor.

PART 2-PRODUCTS

2.1 PRECAST CONCRETE VAULTS AND TANKS

- A. The precast reinforced concrete vault and tank structures shall be designed by a Massachusetts Registered Professional Engineer employed by the Contractor, in accordance with the applicable sections of the following references.
 - 1. Commonwealth of Massachusetts State Building Code, latest edition.

2. American Concrete Institute, ACI 318 "Building Code Requirements for Reinforced Concrete."
 3. AASHTO, "Standard Specification for Highway Bridges."
 4. Precast Concrete Institute, "Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products, MNL-116."
- B. The structures shall be designed for the following loads and possible combinations thereof:
1. Lateral soil pressure=60 PCF (H), where H is the height from grade as shown on the Contract Drawings, to the point of the structure being considered.
 2. Soil weight shall be assumed to be 120 PCF.
 3. AASHTO HS-20-44 loading.
 4. Weight of precast concrete structure.
 5. Initial handling and erection loading, including design of galvanized lifting hooks using safety factor = 4.0.
- C. Investigate buoyancy and soil bearing considerations assuming the groundwater elevation is one-foot below the ground surface.
- D. Concrete shall have a minimum 28-day compressive strength of 5,000 psi using Type II or III Portland cement with 8% maximum content of tricalcium aluminate, ASTM C150. A "normal dosage" of air-entraining agent shall be added to the concrete during the mixing cycle. Reinforcement shall be deformed billet-steel ASTM A615 or 7-wire strand ASTM A416, Grade 270 (if prestressed).
- E. Dimensions and opening sizes and locations shall be as indicated on the Contract Drawings.
- F. Pipe Connections: Vault and tank structures shall have pipe openings to accept the type of pipe specified. Pipe opening shall be minimum size required to receive the pipe and shall be accurately set to conform to the required line and grade. Sewer pipe shall be joined to the wall of the concrete structure with flexible pipe sleeves as indicated on the drawings. Flexible pipe sleeves shall be cast in the walls of the structure during the manufacturing process. Flexible pipe sleeves shall be NPC Kor-N-Seal Pipe-to-Manhole Connector as manufactured by Trelleborg Pipe Seals Milford, Inc., Milford, NH; Z-Lok as manufactured by A-Lok Products, Inc., Tullytown, PA; Tylox CIB Series Cast-In Boot Connector as manufactured by Hamilton Kent, Winchester, TN; or approved equal.
- G. Waterproofing: The exterior surfaces of precast structures shall be given two heavy coats of waterproofing concrete sealer. The material shall be Aqua-Safe Concrete Sealer as manufactured by Bay Oil Company, Chicopee, MA; Bitumastic 300M as manufactured by Carbolite Company, St. Louis, MO; Sonoshield HLM 5000 as manufactured by BASF Corporation Building Systems, Shakopee, MN; ConSeal CS-1800 as manufactured by Concrete Sealants, Inc., Tipp City, OH; or acceptable equivalent products. The waterproofing material shall be applied by brush or spray and in accordance with the instructions of the manufacturer. Time shall be allowed between coats to permit sufficient drying so that the application of the second coat has no effect on the first coat.
- H. Brick Masonry: Bricks shall be sound, hard, uniformly burned, regular, and uniform in shape and size. Underburned or salmon brick shall not be acceptable. Only whole brick shall be used.
1. Bricks for raising manhole and catch basin frames to finished grade shall conform to ASTM C32, Grade MS.

2. Mortar shall be in conformance with ASTM C270, Type M. The mortar shall be composed of one-part Portland cement, 3-1/2 parts sand, and ¼ parts hydrated lime, by volume. Portland cement shall be ASTM C150, Type II; hydrated lime shall be Type S conforming to ASTM D207.
3. Sand shall be washed, cleaned, screened, well-graded with all particles passing a No. 4 sieve, and conform to ASTM C33.

2.2 PRECAST CONCRETE MANHOLES

- A. General: Provide precast reinforced concrete structures as indicated and complying with ASTM C 478.
- B. Manhole Top: Precast concrete of concentric cone, eccentric cone, or flat slab top type, as necessary for the installation as indicated in the Contract Drawings. Tops shall be designed to meet H20 loadings.
- C. Base and Riser Sections: Precast concrete, with base riser section with integral floor. Diameter, base and riser thicknesses shall be as indicated on the Contract Drawings.
- D. Cement: Type II.
- E. Concrete strength: 4,000 psi minimum.
- F. Precast concrete sections shall have tongue and groove joints.
- G. Horizontal Joints: Joints between sections of concrete structures shall be sealed with a flexible, watertight joint, made with preformed butyl rubber joint sealant conforming to ASTM C990 or with a rubber gasket joint conforming to ASTM C443. Sealants and/or gaskets shall be installed in accordance with the manufacturer's written instructions.
- H. Manhole Steps: Steps for manholes shall be non-skid raised edge-front steel reinforced polypropylene plastic type with at least 13-inch-wide stepping surface. Steps shall meet the requirements of ASTM C-478 and AASHTO M-199. Steel shall be 1/2-inch grade 60 conforming to ASTM A615 encapsulated with molded copolymer polypropylene. The polypropylene shall conform to ASTM D-4101. Rungs shall protrude no more than 6 inches from the wall. The portion of the legs to be embedded in the precast section shall have fins and be tapered to ensure a secure bond. Steps shall start a foot above the shelf of the manhole floor and continued twelve inches on center spacing up through the completed height of the unit. The steps shall finish no lower than twenty-four (24)-inches below the rim elevation. Placement into precast walls shall be by a method recommended by the supplier of the precast manhole sections. Steps shall be installed per the manufacturer's specifications.
- I. Pipe Connections: Sewer manhole shall have pipe openings to accept the type of pipe specified. Pipe opening shall be minimum size require to receive the pipe and shall be accurately set to conform to the required line and grade. Sewer pipe shall be joined to the wall of the concrete manhole with flexible manhole sleeves as indicated on the drawings. Flexible manhole sleeves shall be cast in the walls of the manholes during the manufacturing process. Flexible manhole sleeves shall be NPC Kor-N-Seal Pipe-to-Manhole Connector as manufactured by Trelleborg Pipe Seals Milford, Inc., Milford, NH; Z-Lok as manufactured by A-Lok Products, Inc., Tullytown, PA; Tylox CIB Series Cast-In Boot Connector as manufactured by Hamilton Kent, Winchester, TN; or approved equal.

- J. Waterproofing: The exterior surfaces of precast structures shall be given two heavy coats of waterproofing concrete sealer. The material shall be Aqua-Safe Concrete Sealer as manufactured by Bay Oil Company, Chicopee, MA; Bitumastic 300M as manufactured by Carbolite Company, St. Louis, MO; Sonoshield HLM 5000 as manufactured by BASF Corporation Building Systems, Shakopee, MN; ConSeal CS-1800 as manufactured by Concrete Sealants, Inc., Tipp City, OH; or acceptable equivalent products. The waterproofing material shall be applied by brush or spray and in accordance with the instructions of the manufacturer. Time shall be allowed between coats to permit sufficient drying so that the application of the second coat has no effect on the first coat.
- K. Sanitary Sewer Brick Masonry: Bricks shall be sound, hard, uniformly burned, regular, and uniform in shape and size. Underburned or salmon brick shall not be acceptable. Only whole brick shall be used.
 - 1. Bricks for channels and shelves shall conform to ASTM C32, Grade SS except that the mean of five tests for absorptions shall not exceed 8 percent and no individual brick exceed 11 percent.
 - 2. Brick for raising manhole frames to finished grade shall conform to ASTM C32, Grade MS.
 - 3. Mortar shall be in conformance with ASTM C270, Type M. The mortar shall be composed of one-part Portland cement, 3-1/2 parts sand, and ¼ parts hydrated lime, by volume. Portland cement shall be ASTM C150, Type II; hydrated lime shall be Type S conforming to ASTM D207.
 - 4. Sand shall be washed, cleaned, screened, well-graded with all particles passing a No. 4 sieve, and conform to ASTM C33.
- L. In sewer manholes, the invert channel within the structure shall be an inverted arch with bricks laid as stretchers and on edge and so constructed as to conform in shape to the lower half of the pipe. The shelf in manholes shall consist of bricks laid flat and the top of the shelf shall be at the elevation of the top of the pipe, as indicated on the Contract Drawings, and shall be sloped to flow toward the channel.
- M. Inverts in sewer manholes shall conform accurately to size of the adjoining pipe. Side inverts and main inverts where the direction changes shall be laid out in smooth curves of the longest possible radius which is tangent, within the manhole, to the centerline of the adjoining pipe lines.
- N. Sewer manholes shall be constructed with drop connections when the proposed invert of the connection is at least 2 feet above the manhole invert. All drop connections will be of the external type. The drop pipe shall be constructed of SDR 35 PVC sewer pipe. The drop piping and horizontal cleanout sections will be sized the same as the sewer main piping and shall enter the manhole at the invert elevation of the main. The drop portion of the piping shall be secured with anchor straps. The drop piping shall be encased with control density fill.
- O. For all manhole depths greater than 10 feet, the inside diameter of the manholes shall be at least 5'-0".
- P. Safety landings shall be installed inside manholes greater than 16-feet in depth.
- Q. When installing manholes on existing lines and when flows cannot be diverted, drop-over manholes shall be used. Drop-over manholes shall be precast with openings cast in the sidewalls of sufficient size to fit over the existing line(s) to remain in service. Drop-over

manholes shall be set on a precast or cast-in-place concrete base slab. Drop-over manholes shall be manufactured to the same requirements and dimensions as standard manholes.

2.3 MANHOLE FRAMES AND COVERS

- A. Frames and covers shall be of cast iron conforming to the requirements of ASTM A48, Class No. 30 and shall be manufactured by General Foundries Inc., North Brunswick, New Jersey; East Jordan Iron Works (formerly LeBaron Foundry, Inc.), East Jordan, Michigan; Neenah Foundry Company, Neenah, Wisconsin; or approved equal. Manhole covers shall be machined to fit securely and evenly on the frame. Frames and covers shall be designed to accept H20 loads, have a diamond surface finish, and frame height of 6 to 9-inches. Covers shall bear the word "SEWER" in 3-inch high letters. Covers shall be equal to Item Numbers 12665 and 12685 (6" and 8-1/8" frame heights, respectively) as manufactured by General Foundries Inc. Catalog numbers are provided to establish a standard of quality and configuration of castings.

2.4 PVC PIPE

- A. General: Provide pipes of the following materials of class indicated. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.
- B. PVC Sewer Pipe
1. PVC (Polyvinyl Chloride) Gravity Sewer Pipe and Fittings: ASTM D3034, SDR 35, for elastomeric gasket joints. Pipe 18 to 36 inches in diameter shall conform to ASTM F679, T-1 heavy wall. The pipe shall have a SDR ratio of 35 and a pipe stiffness of 46 psi.
 2. Joints: PVC pipe shall have an integral wall bell and spigot push-on joint with elastomeric gaskets secured in place in the bell of the pipe. The bell shall consist of an integral wall section with solid cross section elastomeric gasket, factory assembled, securely locked in place to prevent displacement during assembly. Pipe joints shall conform to ASTM D3212 and elastomeric gaskets shall conform to ASTM F477.
 3. Spigot pipe ends shall be supplied with bevels from the manufacturer to ensure proper insertion. Each spigot end shall have an "assembly stripe" imprinted thereon to which the bell end of the mated pipe will extend upon proper joining of the two pipes.
 4. PVC gravity sewer fittings and accessories shall be as manufactured and furnished by the pipe supplier or approved equal and have bell and spigot configurations compatible with that of the pipe.
- C. PVC Sewer Force Main Pipe
1. PVC Pressure Pipe (Force Main): ASTM D2241, SDR 21, for elastomeric gasket joints. PVC resin compound shall conform to ASTM D1784 and rubber gaskets shall conform to ASTM D1869 and F477. Pipe shall be provided in 20-foot nominal lengths.
 2. Fittings: Fittings shall be made of PVC compound meeting ASTM D1784. Fittings shall be Class 200 and conform to the requirements of SDR 21. Fittings joint gaskets shall conform to ASTM F477.
 3. Thrust blocks shall be used at bends and fittings as shown on the details. In the event that the use of thrust blocks is not practical, the Contractor shall provide an alternate method of joint restraint, at no additional cost, as approved and/or directed by the Engineer.

4. If restrained joints are to be used in lieu of thrust blocks, restraint length values shall be calculated per the manufacturer's standards. Restraint length calculations and restrained joint locations shall be provided by the Contractor and sent to the Engineer for review.

D. PVC Conduit

1. PVC Schedule 40: Provide PVC Pipe, Schedule 40, where shown on the Contract Drawings. Pipe shall comply with ASTM D1785 and be manufactured from virgin PVC plastic conforming to ASTM D1784. Pipe shall be Underwriter's Laboratories listed for use in underground installations.
2. Joints and solvent cements shall conform to ASTM 2564.

2.5 DUCTILE IRON PIPE AND FITTINGS

A. General: Provide pipes of the following materials of class indicated. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.

1. Ductile iron pipe shall be that of a manufacturer who can demonstrate at least five years of successful experience in manufacturing ductile iron pipe. The pipe shall be equipped with push on type, restrained joint, or mechanical joints, as required.
2. All ductile iron drain pipe shall conform to American Water Works Association (AWWA) C150 and AWWA C151.
3. The ductile iron pipe shall be Class 52 and furnished in minimum nominal 18-foot lengths, with Push-on or Mechanical Joints as manufactured by U.S. Pipe and Foundry Company, Atlantic States Cast Iron Pipe Co., Clow Corporation, or approved equal with gaskets conforming to AWWA C111 "Rubber Gasket Joints".
4. The ductile iron sewer pipe shall be PROTECTO 401 Ceramic Epoxy lined and the pipe exterior asphalt seal coated in accordance with AWWA C104.
5. The pipe shall be furnished along with necessary materials and equipment recommended by the manufacturer for use in joining pipe lengths and fittings.
6. Fittings shall be short body ductile iron Class 350 Mechanical Joint, conforming to ANSI Specification AWWA C153, latest edition, for pipe sizes 16 inches and smaller, and Class 350 standard Mechanical Joint fittings conforming to AWWA C110, latest edition, for pipe sizes 16 through 24 inches, unless specifically stated otherwise in the Specifications or on the Contract Drawings. Fittings shall have the same lining and coating as the pipe specified above. All fittings shall be marked with the weight and shall have distinctly cast upon them the pressure rating, the manufacturer's identification, nominal diameter of openings and the number of degrees or fraction of the circle on all bends. Fittings greater than 24 inches shall be as specified above except they shall be Class 250. All accessories (gland, gaskets, T-bolts, and nuts) shall be in accordance with AWWA C111. All mechanical joint bolts (T-bolts) shall be Cor-Ten or equal.
7. Contractor shall provide all adapters and fittings such as transition couplings, as determined in the field, necessary to complete all cross connections, whether or not specifically stated in the Contract Drawings and Specifications.
8. All pipes shall be marked with the class, thickness designation, and initials of the manufacturer.
9. If required the manufacturer shall supply the Engineer with certificates of compliance with these Specifications and certification that each piece of ductile iron pipe has been tested at the foundry with the Ball Impression Test, Ring Bending, or equal.

10. Pipe for use with sleeve-type couplings shall be as specified except that the ends shall be plain (without bells or beads). The ends shall be cast or machined at right angles to the axis.

B. INSPECTION, TESTS, AND ACCEPTANCE FOR DUCTILE IRON PIPE

1. All pipe delivered to the job site shall be accompanied by test reports certifying that the pipe and fittings conform to "AWWA Standard for Ductile Iron Pipe, for Water and Other Liquids" (AWWA H3) and (AWWA C151).
2. All tests shall be made in accordance with the methods prescribed by the above mentioned AWWA Standards, and the acceptance or rejection shall be based on the test results.
3. Pipe which does not conform to the requirements of this contract shall be immediately removed and replaced by the Contractor.
4. All ductile iron pipe to be installed under this Contract may be inspected at the foundry for compliance with these Specifications by an independent testing laboratory selected by the Owner. The Contractor shall require the manufacturer's cooperation in these inspections. The cost of foundry inspection of all pipe approved for this Contract, plus the cost of the inspection of a reasonable amount of disapproved pipe, will be borne by the Owner.

C. SLEEVE COUPLINGS FOR DUCTILE IRON PIPE

1. Sleeve couplings and accessories shall be pressure rated at least equal to that of the pipe. Couplings shall be cast iron and shall be Dresser Style 53 or 153, Rockwell Style 441, Baker Series 4245 or acceptable equivalent product. The couplings shall be provided with Cor-Ten bolts and nuts or approved equal.
2. After assembly, all exterior surfaces including the bolts and nuts shall be thoroughly coated with two coats of heavy-duty protective coating. The interior of the coupling shall be epoxy coated. Coating shall be a minimum of 10 mils. and a maximum of 20 mils. dry film thickness thermosetting epoxy.

2.6 CLEANOUTS

- A. General: Provide cast-iron ferrule and countersunk brass cleanout plug, with round cast-iron access frame and heavy-duty, secured, scoriated cast-iron cover.
- B. The sewer cleanouts shall be minimum 6-inch diameter or sized to match the service pipe, whichever is greater. The cleanout shall be complete with a flush mount over. The cleanout cover shall be clearly marked "SEWER" and shall be minimum eight inches in diameter or two inches greater than the cleanout size, whichever is greater. Cleanouts shall include a watertight cap.

2.7 SEWER COUPLINGS

- A. Sewer Couplings shall be pressure rated at least equal to that of the pipe. The coupling sleeve shall be 1/4-inch minimum thickness elastomeric polyvinylchloride with a minimum tensile strength of 1500 psi. The sleeve shall fit snugly onto the pipe to be joined and be resistant to common chemicals present in sewerage. Adjustable pipe clamps shall consist of a slotted band that mate with the worm gear screw and a screw housing all manufactured of stainless steel, and suitable for underground service.

2.8 SANITARY SEWER PUMP STATION

A. Precast Concrete Chambers

1. The wet well and valve pit shall be precast concrete structures of the dimensions shown on the Contract Documents. Refer to Sections 2.1 and 2.2 for precast concrete structure material requirements.
2. The wet well and valve pit shall each receive two coats of bituminous damp proofing on both the inside and outside surfaces of the structures.
3. All inlet and outlet connections to the wet well and valve pit shall be watertight and shall be installed at the elevations as shown on the Contract Documents.
 - a. The connections shall be sealed with modular, mechanical seals, consisting of rubber links shaped to continuously fill the annular space between the pipe and the wall openings. The pressure plates shall be molded of glass reinforced nylon. Hardware shall be mild steel with a 60,000-psi minimum tensile strength and 2-part Zinc Dichromate coating per ASTM B-633 and Organic Coating, tested in accordance with ASTM B-117 to pass a 1,500-hour salt spray test (or 316 Stainless Steel).
 - b. Sleeves shall be provided at all wall openings for piping. The sleeves shall be steel made from heavy-wall welded or seamless pipe cast into the wall of the wet well and valve pit. A full circle waterstop plate acts a positive seal and anchor to prevent thrust movement. The 2" collar/waterstop shall be continuously welded on both sides. The sleeves shall be hot dip galvanized coated.
4. The Contractor shall submit buoyancy calculations for sewer pump station structures assuming groundwater is 1 foot feet below finish grade. If buoyancy is determined to be an issue the structure(s) shall be modified to prevent uplift. All buoyancy calculations and sewer pump station structure designs shall be prepared and stamped by a Professional Engineer licensed in the Commonwealth of Massachusetts.

B. Access Hatches

1. The access hatches shall be manufactured by the Bilco Company, Halliday Products, U.S.F. Fabrication, or approved equal.
2. Wet well and valve pit access doors shall be installed where indicated on the plans. The access doors shall be pre-assembled from the manufacturer.
3. The cover shall be reinforced to support H-20-wheel loading. Operation of the cover shall be smooth and easy with controlled operation throughout the entire arc of opening and closing. Operation of the cover shall not be affected by the temperature. The entire door, including all hardware components, shall be highly corrosion resistant. The cover shall be ¼" aluminum diamond pattern.
4. The channel frame shall be ¼" extruded aluminum with bend down anchor tabs around the perimeter. A continuous EPDM gasket shall be mechanically attached to the aluminum frame to create a barrier around the entire perimeter of the cover and significantly reduce the amount of dirt and debris that may enter the channel frame.
5. The hinges shall be specifically designed for horizontal installation and shall be through bolted to the cover with tamper-proof Type 316 stainless steel lock bolts and shall be through bolted to the frame with Type 316 stainless steel bolts and locknuts.
6. Provide a 1-1/2" drain coupling located in the right front corner of the channel frame.
7. Lifting Mechanisms: The manufacturer shall provide the required number and size of compression spring operators enclosed in telescopic tubes to provide, smooth, easy, and controlled cover operation throughout the entire arc of opening and to act as a

check in retarding downward motion of the cover when closing. The upper tube shall be the outer tube to prevent accumulation of moisture, grit, and debris inside the lower tube assembly. The lower tube shall interlock with a flanged support shoe fastened to a formed 1/4" gusset support plate.

8. A removable exterior turn/lift handle with a spring-loaded ball detent shall be provided to open the cover and the latch release shall be protected by a flush, gasketed, removable screw plug.
9. Hardware:
 - a. Hinges: Heavy forged Type 316 stainless steel hinges, each having a minimum 1/4" diameter Type 316 stainless steel pin, shall be provided and shall pivot so the cover does not protrude into the channel frame.
 - b. Cover shall be equipped with a hold arm which automatically locks the cover in the open position.
 - c. Cover shall be fitted with the required number and size of compression spring operators. Springs and spring tubes shall be Type 316 stainless steel.
 - d. A Type 316 stainless steel snap lock with fixed handle shall be mounted on the underside of the cover.
 - e. Hardware shall be Type 316 stainless steel throughout.
10. Finishes: Factory finish shall be mill finish aluminum with bituminous coating applied to the exterior of the frame.

C. Sanitary Sewer Pump System

1. Pumps shall be of the submersible grinder type with 10 vane impellor. All openings in the pump impeller and volute case shall be large enough to pass a 2" diameter sphere. The Contractor shall furnish and install a complete non-clog pumping system consisting of submersible non-clog pumps and lift-out rail system, valves, controls, access covers and all other appurtenances to make a complete system. Pumps, control panel, and rail packages shall all be supplied by the same pump supplier.
2. The Contractor shall provide a duplex pump assembly consisting of two non-clog submersible grinder pumps with a discharge flange. Pump and motor assembly shall be FM listed for Class 1, Group D hazardous location service. A non-witness performance test on each pump at the pump manufacturer shall be performed to guarantee pump performance. The results of the tests shall be submitted to the designer for review and comment. Each pump shall have a capacity of 20 gallons per minute (gpm) at a total dynamic head (TDH) of 25 feet and shall use a 1.0 HP motor operating at 3450 RPM.
3. Motor
 - a. The pump motor shall be of the sealed submersible type rated 1.0 horsepower at 3450 RPM, 60 Hertz. The motor shall be single.
 - b. Stator winding shall be of the open type with Class H inverter duty insulation good for 356°F (180°C) maximum operating temperature. Winding housing shall be filled with clean high dielectric oil that lubricates bearings and seals and transfers heat from windings and rotor to outer shell. Air-filled motors which do not have the superior heat dissipating capabilities of oil-filled motors shall not be considered equal.
 - c. Motor shall have two heavy duty ball bearings to support pump shaft and take radial and thrust loads and a sleeve guide bushing directly above the lower seal to take radial load and act as flame path for seal chamber. Ball bearings shall be

- designed for 50,000 hours B-10 life. Stator shall be heat shrunk into motor assembly.
- d. A heat sensor thermostat shall be attached to and embedded in the winding and be connected in series with the motor starter contactor coil to stop motor if temperature of winding is more than 248°F (120°C). Thermostat to reset automatically when motor cools to safe operating temperature. Three heat sensors to be used on three phase motors.
 - e. Common motor pump shaft shall be of 416 stainless steel.
4. Seals
- a. Motor shall be protected by two mechanical seals mounted in tandem with a seal chamber between the seals. Seal chamber shall be oil filled to lubricate seal face and to transmit heat from shaft to outer shell.
 - b. Seal face shall be carbon and ceramic and lapped to a flatness of one light band.
 - c. A double electrode shall be mounted in the seal chamber to detect any water entering the chamber through the lower seal. Water in the chamber shall cause a red light to turn on at the control box. This signal shall not stop the motor but shall act as a warning only, indicating service is required.
5. Impeller
- a. The impeller shall be ductile iron and solids handling enclosed type. Vane inlet tips shall be carefully rounded to prevent stringy material from catching the vanes. Pump-out vane shall be used in front and back chamber. Impeller shall be dynamically balanced. Impeller shall be driven by stainless steel shaft key and impeller held in place with lock screw and washer.
 - b. Impeller and motor shall lift off as a unit without disturbing discharge piping.
6. Pump Case
- a. The volute case shall be of cast iron and have a flanged center line discharge. Discharge flange shall be 4-inch standard with bolt holes straddling centerline.
 - b. A bronze wear ring shall be pressed into the case for guiding the impeller neck and to prevent corrosion freeze-up. Wear ring shall be held from rotating by locking with a stainless-steel set screw in end of ring.
7. Pump and Motor Castings
- a. All castings shall be of high tensile cast iron and shall be treated with phosphate and chromate rinse. All fasteners shall be 302 stainless steel.
8. Bearing End Cap
- a. Upper motor bearing cap shall be a separate casting for easy mounting and replacement.
9. Power Cables
- a. Power cord and control cord shall be double sealed. The power and control conductor shall be single strand sealed with epoxy potting compound and then clamped in place with rubber seal bushing to seal outer jacket against leakage and to provide for strain pull. Cords shall withstand a pull of 300 pounds to meet FM requirements.
 - b. Insulation of power and control cords shall be type SOOW. Both control and power cords shall have a green carrier ground conductor that attaches to motor frame.
10. Lift-Out Rail System

- a. Each submersible pump shall be provided with a lift-out slide rail system as supplied by the same pump supplier. The lift out rail system shall be compatible with pumps supplied. The lift-out rail system shall be of non-sparking design and shall be listed for explosion-proof service.
- b. Each lift-out system shall consist of a ductile iron discharge base, brass faced pump attaching and sealing plate, brass pump guide plate, and cast-iron elbow. All exposed nuts, bolts, and fasteners shall be 300 series stainless steel. No fabricated steel parts shall be used.
- c. The discharge elbow shall be 4"x4". The elbow shall bolt onto the base and have standard 125 lb. flanges.
- d. A sealing plate shall be attached to the pump. A simple downward sliding motion of the pump and guide plate on the guide rails shall cause the unit to be automatically connected and sealed to the base. The mating face of the sealing plate and base shall be machined to provide a metal-to-metal, leak-proof seal at all operating pressures.
- e. The guide rails shall consist of two rail pipes used to guide the pump from the surface to the discharge base connection. The guide rails shall be 1-1/2" schedule 40 stainless steel pipe. The weight of the pump shall bear solely on the discharge base and not on the guide rails. Rail systems which require the pump to be supported by legs which might interfere with the flow of solids into the pump suction will not be considered equal. The guide rails shall be firmly attached to the access hatch frame. Systems deeper than 21 feet shall use an intermediate guide for each 21 feet of wet well depth.
- f. An adequate length of stainless steel lifting chains shall be supplied for removing the pumps. The chains shall be of sufficient length and shall include an adequate number of lifting rings to provide ease of pump removal.

11. Piping

- a. The piping in the wet well, valve vault, and sanitary sewer force main cleanout manhole shall be flanged ductile iron pipe in the sizes indicated on the Contract Drawings. Flanged pipe shall be made with a minimum Class 53 thickness pipe in accordance with AWWA/ANSI C151/A21.51 and flanges screwed on, faced and drilled in accordance with AWWA/ANSI C110/A21.10 and AWWA/ANSI C115/A21.15. Flanged fittings shall be ductile iron in accordance with ANSI/AWWA C110/A21.10 and 125# ANSI B16.1 faced and drilled. All exterior piping from the valve vault to the cleanout manhole and from the cleanout manhole to the discharge manhole shall be PVC, SDR-21. The discharge piping shall exit the valve vault with at least 5 feet of cover. The Contractor shall supply the necessary fittings to transition from ductile iron piping to PVC piping.

12. Valves

- a. Resilient wedge gate valves shall be flanged, ductile iron body, resilient seated type. The valves shall be designed for 250-psi working pressure and 400-psi test pressure. Valves shall have O ring seals and a nonrising stem. Valves shall meet or exceed the requirements of AWWA C-509 and C-515 and will be UL listed and FM approved. Valves shall have wheel handle operators.
- b. Check valves shall be flanged, of the full body type, with a domed access cover and be of the swing type. The valve shall be designed, manufactured and tested in accordance with the requirements of AWWA C-508.
 - 1) The valves shall be provided with flanges in accordance with ANSI B16.1, Class 125.

- 2) The valve body shall be full flow equal to nominal pipe diameter at all points through the valve. The 4 in. (350mm) valve shall be capable of passing a 3 in. (75mm) sphere. The seating surface shall be on a 45° angle to minimize disc travel. A threaded port with pipe plug shall be provided on the bottom of the valve to allow for field installation of a backflow actuator or oil cushion without special tools or removing the valve from the line.
 - 3) The top access port shall be full size, allowing removal of the disc without removing the valve from the line. The access cover shall be domed in shape to provide flushing action over the disc for operating in lines containing high solids content. A threaded port with pipe plug shall be provided in the access cover to allow for field installation of a mechanical, disc position indicator.
 - 4) The disc shall be of one-piece construction, precision molded with an integral O-ring type sealing surface, and contain alloy steel and nylon reinforcement in the flexible hinge area. The flex portion of the disc shall be warranted for twenty-five years. Non-Slam closing characteristics shall be provided through a short 35° disc stroke and a memory disc return action to provide a cracking pressure of 0.25 psig.
 - 5) The valve disc shall be cycle tested 1,000,000 times in accordance with ANSI/AWWA C508 and show no signs of wear, cracking, or distortion to the valve disc or seat and shall remain drop tight at both high and low pressures.
 - 6) The valve body and cover shall be constructed of ASTM A536 Grade 65-45-12 ductile iron.
 - 7) The disc shall be precision molded Buna-N (NBR), ASTM D2000-BG.
 - 8) A screw-type backflow actuator shall be provided to allow opening of the valve during no-flow conditions. Buna-N seals shall be used to seal the stainless-steel stem in a Lead-Free bronze bushing. The backflow device shall be of the rising-stem type to indicate position. A stainless-steel T-handle shall be provided for ease of operation.
 - 9) A mechanical indicator shall be provided to provide disc position indication on the valves. The indicator shall have continuous contact with the disc under all operating conditions to assure accurate disc position indication.
 - 10) The valve shall be provided with a bottom mounted oil dashpot (oil cushion) to provide hydraulic control of the final 10% of valve closure and reduce valve slam and water hammer normally associated with rapid flow reversal conditions on pump shut down. The dashpot shall consist of a high-pressure hydraulic cylinder, adjustable external flow control valve, oil reservoir, pressure gauge, stainless steel air inlet valve, and piping designed to control the closing speed of the last 10% of travel in 1-5 seconds. A threaded brass dashpot bushing unit with a grease fitting for lubrication shall connect the cylinder to the valve and shall have an air gap to prevent hydraulic fluid from entering the valve and contaminating the water system. A snubber rod fitted with O-ring seals and rod wiper scrapers shall make contact with the lower portion of the disc's stainless-steel strike plate.
 - 11) Check valves shall have a working pressure rating of 250psi. All valves shall be hydrostatically tested and seat tested to demonstrate zero leakage.
 - 12) The exterior and interior of the valve shall be coated with an NSF/ANSI 61 approved fusion bonded epoxy coating.
 - 13) Check valves shall be suitable for horizontal mounting.
13. Float Switches

- a. Pump(s) on, off, and alarm levels shall be controlled by non-mercury mechanical float switches. Switches shall consist of a non-mercury mechanical float switch sealed in a corrosion-resistant polypropylene housing with a minimum of 18-gauge, 2 wire, SJOW/A jacketed cable. The cable shall be of sufficient length to reach the junction box with no splices. The level controls shall be suspended from a stainless-steel bracket so that adjustment or replacement may be done without the use of any tools. Level controls shall be UL/CSA listed. The float switches shall be set at the elevations indicated on the Contract Drawings.

14. Three Phase Duplex Control Panel

- a. A NEMA 3R steel three phase duplex control panel shall be mounted as indicated on the Contract Documents. The Contractor shall provide all necessary hardware, conduit, and cables to connect the control panel to the power supply from the building and to the pump station wet well.
- b. All electrical components shall be mounted in a NEMA 3R galvanized steel enclosure. The enclosure shall be 14-gauge galvanized steel and shall have a hasp for padlocking.
- c. A separate hinged dead front inner door shall be provided in the enclosure. All control switches, lights, and overload resets shall be mounted through the inner door. The pump circuit breaker and control circuit breaker shall be mounted with operating handles through the inner door and shall have locking tabs that prevent the inner door from being opened with the breakers in the "ON" position.
- d. Both the inner door and the back panel shall be a minimum of 14-gauge galvanized steel, and shall be painted on both sides with a white enamel finish.
- e. Equipment mounted in the control panel shall include: pump circuit breaker, control circuit breaker, alarm circuit fuse, control circuit fuse, I.E.C. rated motor starter with 3-pole ambient compensated bi-metal overload relay for each pump, two (2) pump hand-off-auto switches, alarm test switch, two (2) pump run lights, seal leak lights, alternator relay (solid state), control circuit transformer with primary fusing, override relay, terminal blocks, lead/lag alternate selector switch, ground lugs, and all necessary wiring and brackets.
- f. The control panel shall be fitted with a red lexan (polycarbonate) alarm light. The light shall be approximately 3" high by 3-1/2" diameter. The globe shall be mounted on top of the enclosure with a neoprene gasket. The lens cannot be removed from the exterior of the enclosure. The lens may be removed by entering the interior of the enclosure and removing four (4) #8 screws. The bulb shall be 25-watt minimum high intensity-medium base type. The bulb shall be easily replaced by removing a thumb screw from the support bracket on the interior of the panel.
- g. The alarm shall have a bright glow and flash during high water conditions. The alarm light will go out when the water level drops.
- h. An elapsed time meter shall be provided for each pump to record the actual running time of the motor. The elapsed time meter shall be energized by an auxiliary contact from the motor starter or contactor and be wired in parallel with the pump run light. The elapsed time meter shall have a maximum reading of 99,999.99 hours and be non-resettable.
- i. A set of dry contacts shall be provided for the remote monitoring of a panel function. Functions may include high water, low water, seal failure, or pump running conditions. The dry contacts shall close upon the detection of said condition. Contacts shall be rated for 3 amps.

- j. The panel shall contain a control circuit transformer, which shall reduce the control circuit voltage to 24 volts. The 24 volts shall be supplied to all lights, switches, relays, and floats.
 - k. Intrinsically safe relays shall be provided for the float switches in the wet well. The float switches shall be incapable of releasing sufficient electrical or thermal energy under normal conditions to cause ignition of a specific hazardous atmospheric mixture suitable for use in Division I locations. The intrinsically safe relay shall read circuits up to 3,000 ohms resistance. The power transmitted through the float switch shall be held to a maximum of 12 vdc and 3 ma. The duplex panel shall use three relays (pump off-on, override, high water).
 - l. A lightning arrestor shall be supplied in the Control Panel. The arrestor shall protect the equipment from overvoltages caused by lightning discharges. The arrestor shall be rated at 650 volts RMS L-G.
 - m. An acknowledge alarm circuit with horn shall be provided to indicate an alarm condition. The horn shall be energized by either the alarm float switch or the alarm test switch and operate in conjunction with the alarm light. The horn shall be weatherproof and be rated for 103 db. at 10 ft. There shall be an exterior acknowledge switch that will silence the horn but allow the light to remain flashing during an alarm condition.
 - n. A low-level cutoff and alarm circuit shall be supplied in the control panel. The circuit shall override the entire system and prevent pump operation below a pre-determined level. The circuit shall also signal the panel alarm. The circuit shall use a normally closed float switch.
 - o. The Control Panel shall contain a phase monitor/relay. The monitor/relay shall protect pump motors against phase loss, under voltage, and phase reversal conditions. When incorrect phase sequence or phase loss occurs or if the three-phase voltages fall below the drop out voltages (field adjustable), the monitor/relay shall drop out the pumps and signal the panel alarm. The pumps and alarm shall return to normal after the condition(s) are corrected.
 - p. The Control Panel shall contain seal leak circuitry. The seal leak circuitry shall contain a test switch and light that will allow the integrity of the circuit to be tested.
 - q. All internal wiring shall be neat and color coded. Each wire shall be different color or stripe (except for ground), and all incoming wires shall terminate into a box clamp type terminal block. All control wires shall be 14 Ga. Type TEW rated for 105 degrees Celsius.
 - r. A schematic diagram (showing wire color) shall be permanently fastened to the inside of the enclosure. An Installation and Service Manual shall also be included with each control panel.
 - s. The control panel shall be U.L. listed as an assembly.
15. Control System
- a. The control system for the pump chamber shall have the capability to perform the following tasks: start lead pump (Pump Number 1) when water level reaches lead pump "On" elevation, start lag pump (Pump Number 2) when water level reaches lag pump "On" elevation, turn the operating pump(s) off when the water level reaches pump(s) "Off" elevation in wet well, activate an alarm when the level reaches a high water level, and activate an alarm condition if the water level reaches a low level in the chamber. All alarm and pump on and off levels shall be activated by float switches placed at the elevations shown on the Contract Drawings. The control panel also shall be capable of alternating starts of Pump

Number 1 and 2. The high-water alarm condition shall activate an alarm horn and an alarm beacon mounted on the top of the control cabinet. Within the control panel, lights shall be provided and labeled for each of the alarm conditions to make it possible to determine what caused the alarm. The Contractor is responsible for providing a fully functioning system as described.

16. Alarm Signaling

- a. The Contractor shall provide alarm signaling as indicated for the pump station at the control panel. Any and all alarm conditions from the pump chamber shall be relayed to the annunciator panel as a single "Pump Chamber Alarm Condition". The annunciator panel shall be mounted in the building in a location as indicated on the Electrical Drawings.

2.9 IDENTIFICATION

- A. Detectable Underground Warning Tapes: Acid and alkali-resistant, polyethylene plastic film warning tape, 6-inches wide by 4-mils. minimum thickness, with continuously printed caption in black letters "CAUTION – xxxxx LINE BURIED BELOW." The text and color of the tape shall be as shown in the table below. The tape shall have a metallic core encased in a protective jacket for corrosion protection and be detectable by a metal detector when the tape is buried up to 2.5 feet deep.

Color	Utility
Safety Red	Electric
High Visibility Safety Yellow	Gas, Oil, Steam
Safety Alert Orange	Telephone, Communications, Cable Television
Safety Precaution Blue	Water System, Irrigation
Safety Green	Sanitary Sewer, Storm Sewer

PART 3-EXECUTION

3.1 GENERAL INSTALLATION

- A. General Locations and Arrangements: Contract Drawings indicate the general location and arrangement of the underground sanitary sewer system piping. Location and arrangement of piping layout take into account many design considerations. Install the piping as indicated, to the extent practical. Any modifications to the layout of the sewer system shall be submitted to the Engineer for review and approval at least five days prior to the start of the affected work.
- B. Install piping beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings in accordance with manufacturer's recommendations, accepted practices, and utility owner's requirements. Maintain swab or drag in line and pull past each joint as it is completed.
- C. All piping shall be laid in the dry. Adequate measures shall be taken to prevent floatation of pipe in the trench.

- D. Whenever encountered within the trench, existing abandoned water, sewer, and/or drain lines shall be removed within the trench limits, unless otherwise noted. The remaining portion of the abandoned lines shall be plugged at all open ends.
- E. When bell and spigot pipes are used, bell holes shall be dug in the bedding to accommodate the bells. They shall be deep enough to ensure that the bell does not bear on the bottom of the hole but shall be excessively wide in the longitudinal direction of the installation.
- F. Use manholes for changes in direction, except where a fitting is indicated. Use fittings for branch connections, except where direct tap into existing sewer is indicated.
- G. Use proper size increasers, reducers, and couplings, where different size or material of pipes and fittings are connected. Reduction of the size of piping in the direction of flow is prohibited without the written approval of the Engineer.
- H. Install piping pitched down in direction of flow as indicated on the Contract Drawings.
- I. Extend sanitary sewerage system piping to connect to building sanitary drains, of sizes and in locations indicated on the Contract Drawings.
- J. Install piping in accordance with governing authorities having jurisdiction, except where more stringent requirements are indicated.
- K. Acceptance of Pipe: Acceptance will be on the basis of tests specified herein before. The quality of all materials used in the pipe, the process of manufacture, and the finished pipe shall be subject to review by the Engineer. Inspection may be made at the place of manufacture, or on the work site after delivery or at both places and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though sample pipe units may have been accepted as satisfactory at the place of manufacture. All pipe which is rejected shall be immediately removed from the project site by the Contractor.
- L. Pipe Storage: Pipe sections shall not be stored on areas over the newly laid pipe or other pipelines which might be damaged by the superimposed load, and storage sections shall be restricted to approved areas.
- M. Handling Pipe: Each pipe unit shall be handled into its position in the trench only in such manner and by such means, as the Engineer accepts as satisfactory. The Contractor will be required to furnish suitable devices to permit satisfactory support of all parts of the pipe unit when it is lifted.
- N. Laying Pipe: Except where a concrete cradle or envelope is required, the pipe shall be laid in a crushed stone cradle. In trenches, no blocking or supporting of the piping by concrete, stones, bricks, wooden wedges, or method other than bedding the pipe on crushed stone will be permitted. Each length of pipe shall be shoved home against the pipe previously laid and held securely in position. Joints shall not be "pulled" or "cramped" without approval of the Engineer.
- O. Jointing Pipe: After the pipe are aligned in the trench and are ready to be jointed, all joint surfaces shall be cleaned.
- P. Alignment and Placement: All pipe shall be laid with extreme care as to grade and alignment. Each pipe shall be so laid as to form a close joint with the next adjoining pipe and bring the inverts continuously to the required grade.

1. Stakeout of drain work and setting of line and grade is the responsibility of the Contractor.
 2. The Contractor shall establish centerline and offset stakes at each manhole, plus one intermediate centerline and offset stake as a check point between manholes. Laser aligning shall not be used to establish a continuous line in excess of 400-feet.
- Q. Cleaning: Care shall be taken to prevent earth, water, and other materials from entering the pipeline. As soon as possible after the pipe and manholes are completed, the Contractor shall clean out the pipeline and manholes being careful to prevent soil, water, and debris from entering any existing sewer system.
1. Place plugs in end of uncompleted conduit at end of day or whenever work stops.
 2. Flush lines between manholes to remove collected debris.
- R. Review of Completed Sanitary Sewer System: The completed sewer system shall be visually inspected by the Owner's Representative. If the visual observation of the completed sewer or any part thereof shows any pipe, manhole, or joint to be of defective work or material, the defect shall be replaced or repaired as directed by the Engineer or the Owner's Representative. The Contractor shall coordinate and provide site access for inspection. All repairs or replacement of deficient or incomplete work shall be performed by the Contractor at no cost to the Owner.

3.2 INSTALLATION OF SEWER MANHOLES

- A. The bases shall be supported on a compacted level foundation of gravel borrow a minimum of 12 inches thick. Crushed stone may be substituted for gravel borrow if field conditions at the bottom of the excavation are wet.
- B. The Contractor shall install the manholes as soon as the pipe laying reaches the location of the manhole.
- C. The Contractor shall accurately locate each manhole and set accurate templates to conform to the required line and grade. Any manhole which is not installed in the correct location or oriented improperly shall be removed and rebuilt in its proper location, alignment, and orientation at no additional cost to the Owner.
- D. Manhole risers and tops shall be installed using approved butyl rubber sealant or rubber gasket for sealing joints of manhole risers and tops; jointing shall be performed in accordance with the manufacturer's recommendations. Manhole risers and tops shall be installed level and plumb. Water shall not be permitted to rise over newly made joints, nor until after inspection as to their acceptability. All jointing shall be done in a manner to ensure watertight joints.
- E. Openings shall be provided in the precast concrete manhole risers to receive entering pipes and these openings shall be made at the place of manufacture. Connection of sanitary pipes to manholes shall be made by means of a flexible rubber sleeve/boot cast integral with the structure sidewall.
- F. Care shall be taken to ensure the openings are made to permit setting of the entering pipe at its correct elevation as indicated or directed. Manhole risers and tops shall be installed so the manhole steps shall be in alignment.
- G. All holes used for handling shall be thoroughly plugged with non-shrink grout.

- H. Cutting or tampering in the field, for purpose of creating new sidewall openings or altering existing openings, will not be permitted without approval of the Engineer.
- I. All interior manhole joints where the sealing material is not flush with the inside wall shall be grouted with non-shrink mortar and finished by hand/wet-brush.
- J. Clean all debris, mortar, and soil from the bottom of all structures prior to final acceptance of the project.

3.3 INSTALLATION OF PRECAST CONCRETE TANKS AND VAULTS

- A. The bases shall be supported on a compacted level foundation of gravel borrow a minimum of 12 inches thick. Crushed stone may be substituted for gravel borrow if field conditions at the bottom of the excavation are wet.
- B. The precast base shall be placed level at the specified grade. The entire base should be in contact with the underlying compacted granular material. Subsequent sections, complete with joint seals, shall be installed in accordance with the precast concrete manufacturer's recommendations. Structure sections shall be installed level and plumb. Water shall not be permitted to rise over newly made joints, nor until after inspection as to their acceptability. All jointing shall be done in a manner to ensure watertight joints.
- C. Adjustment of the structure can be performed by lifting the upper sections free of the excavated area, re-leveling the base, and re-installing the sections. Damaged sections and gaskets shall be repaired or replaced as necessary. Once the structure has been constructed, any lift holes shall be plugged watertight with mortar or non-shrink grout. Any precast structure which is not installed in the correct location or oriented improperly shall be removed and rebuilt in its proper location, alignment, and orientation at no additional cost to the Owner.
- D. Inlet and outlet pipes should be securely set into the structure using approved pipe seals (flexible boot connections, where applicable) so that the structure is watertight. Care shall be taken to ensure that the openings are made to permit setting of the entering pipe at its correct elevation as indicated or directed. Cutting or tampering in the field, for purpose of creating new sidewall openings or altering existing openings, will not be permitted.
- E. Grade rings shall be installed to set the frame and cover at the required elevation. The grade rings shall be laid in a full bed of mortar with successive units being joined using sealant recommended by the manufacturer. Frames for the cover shall be set in a full bed of mortar at the elevation specified.
- F. Clean all debris, mortar, and soil from the bottom of all structures prior to final acceptance of the project.

3.4 SETTING MANHOLE FRAMES AND COVERS

- A. Manhole frames shall be set with tops conforming accurately to the grade of the pavement or finished ground surface as indicated on the Contract Drawings or as directed.
- B. Brick shall be used to bring the frame and cover to the required elevation.
 - 1. Frames shall be set concentric with the opening in the top of the manhole on two to four courses of brick in a full bed of mortar. A thick ring of mortar extending to the outer edge of brick or concrete shall be placed all around the bottom flange of the cast iron

frame. The mortar shall be smoothly finished to a height of 5 inches above the flange for 8-inch frames and sloped to shed water away from the frame.

2. Completed brick installation shall be coated with mortar at least a $\frac{3}{4}$ inch thick on the outside to provide a fully sealed and watertight collar between the top manhole section and the cover frame.
 3. Only clean bricks shall be used in brick work to adjust frame elevations. The brick shall be moistened by suitable means.
- C. The castings of structures located within the pavement area shall not be completely set to the established grade until the bottom course of pavement has been laid. The final setting of all other casting shall be performed at the proper stage of construction.
- D. Manhole covers shall be left in place in the frame until completion of other work at the manholes.

3.5 PVC PIPE

- A. General: Install piping in accordance with governing authorities having jurisdiction, except where more stringent requirements are indicated.
- B. PIPE HANDLING
1. All pipe and fittings shall be carefully handled from the truck onto the ground and into the trench or excavation so as to prevent damage to the pipe. Pipes shall be kept free of dirt and foreign material especially on the inside. Joint ends of pipe shall especially be kept clean.
 2. Pipe stored on site shall be protected from direct sun light and suitably ventilated.
 3. Pipe or fittings shall not be dropped. All pipe or fittings shall be examined before laying, and no piece shall be installed which is found to be defective.
- C. ALIGNMENT AND PLACEMENT OF PVC PIPE
1. Bedding material for the pipe must be installed with care in the area around the pipe. Bedding material must be placed to provide uniform and adequate support under pipe. Do not use blocking to bring pipe up to grade.
 2. Provide bell holes at each joint to permit joint to be assembled properly while maintaining uniform pipe support.
 3. Place and consolidate the bedding material under the pipe haunch to provide adequate side support while avoiding both vertical and lateral displacement of pipe.
 4. Initial backfill must be completed to a point at least 12-inches over the top of the pipe and be hand placed. Use little or no tamping of initial backfill directly over the top of pipe. Compaction methods may be utilized during final backfilling.
 5. No length of pipe shall be laid until the proceeding lengths of pipe have been thoroughly embedded in place, to prevent movement or disturbance of the pipe alignment.
 6. Full lengths of pipe shall be used in the installation except that partial lengths may be used at the entrance to structures, and to accommodate the required locations of service connection fittings.
 7. Pipe entrances to structures shall be cut flush with the inside face of the structure, and cut ends of the pipe surface within the structure shall be properly rounded and finished so that there will be no protrusion, ragged edges or imperfections that will impede or affect the hydraulic characteristics of the sewage flow. The method of cutting and finishing shall be subject to the approval of the Engineer.

8. The Contractor shall protect the installation at all times during construction. The movement of construction equipment, vehicles and loads over and adjacent to any pipe shall be performed at the Contractor's own risk.
9. Sewer pipes shall be laid to the required grades by use of a laser and target system, unless otherwise specifically approved by the Engineer.
10. Separation Between Sewer Lines and Water Lines:
 - a. A minimum horizontal separation of ten (10) feet shall be maintained between proposed sewer lines and existing water lines. The distance shall be measured edge to edge. In cases where it is not practical to maintain a ten foot separation, it is permitted to install a sewer line closer to a water line, provided that the sewer line is laid in a separate trench or on an undisturbed earth shelf located eighteen (18) inches above the top of sewer. In either case, the elevation of the top of the sewer shall be at least 18 inches below the bottom of the water line.
 - b. Whenever sewers must cross under water lines, the sewer shall be laid at such an elevation that the top of the sewer is at least 18 inches below the bottom of the water line. When the elevation of the sewer cannot be varied to provide the 18 inches of vertical clearance, the water line shall be relocated to provide this separation or reconstructed with mechanical –joint pipe for a distance of 10 feet on each side of the sewer. One full length of water pipe shall be centered over the sewer so that both joints will be as far from the sewer as possible.
 - c. When it is impossible to obtain horizontal and/or vertical separation as indicated above, both the water line and sewer line shall be constructed of mechanical joint ductile iron pipe for a distance of ten (10) feet to either side of the respective centerline. The water line shall be cement lined and the sewer line shall be provided with ceramic epoxy lining for sewer applications. Both pipes shall be pressure tested by an approved method to assure water-tightness or both pipes shall be encased in control density fill. One (1) full length of water pipe shall be centered over the sewer at the crossing.
11. Jointing of PVC sewer pipe and fittings shall be done in accordance with the printed recommendations of the manufacturer and as specified. The bell end of the pipe shall be thoroughly cleaned. The joint surfaces and the gasket shall be lubricated prior to making up the joint. The position of the gasket shall be checked to ensure the joint has been properly made and is watertight. Care shall be taken not to exceed the manufacturer's recommended maximum deflection allowed for each joint.
12. PVC pipe shall be pushed home by hand or with the use of bar and block. The use of power equipment, such as a backhoe bucket, is not acceptable.
13. Field-cut pipe ends shall be cut square and the pipe surface beveled to the size and shape of a factory-finished beveled end. All sharp edges shall be rounded off.
14. Detectable warning tape shall also be installed 2-feet below the existing ground surfaces for later use in locating the pipe's exact position.

3.6 PLACEMENT OF DUCTILE IRON PIPE AND FITTINGS

- A. Care shall be taken in loading, transportation, and unloading to prevent injury to the pipe or coatings. Pipe or fittings shall not be dropped. All pipe and fittings shall be examined before placement, and no piece shall be installed which is found to be defective. Any damage to the pipe coatings shall be repaired as directed by the Engineer.
- B. If any defective pipe is discovered after it has been placed, it shall be removed and replaced with a sound pipe in a satisfactory manner by the Contractor, at his own expense. All pipe

and fittings shall be kept clean until they are used in the work, be thoroughly cleaned before placement, and when placed, shall conform to the lines and grades required. Ductile iron pipe and fittings shall be installed in accordance with requirements of AWWA Standard Specification C600 except as otherwise provided herein. A firm even bearing throughout the length of the pipe shall be constructed by compacting gravel borrow around the pipe and up to the springline.

1. Blocking will not be permitted.
- C. All pipes shall be sound and clean before placement. When pipe laying is not in progress, including lunchtime, the open ends of the pipe shall be temporarily closed by watertight plug or other acceptable means. Alignment shall be maintained during placement. The deflection at joints shall not exceed sixty percent of that recommended by the manufacturer. Fittings, in addition to those shown on the plans, shall be provided, if required, in crossing utilities, which may be encountered upon opening the trench. Solid sleeves shall be used only where allowed by the Engineer.
- D. When cutting pipe is required, the cutting shall be done by machine, leaving a smooth cut at right angles to the axis of the pipe. Cut ends of pipe to be used with a push-on type bell shall be beveled to conform to the manufactured spigot end.
- E. The Contractor shall take care not to damage pipe by impact, bending, compression, or abrasion during handling, and installation. Joint ends of pipe especially shall be kept clean.
- F. Pipe shall be stored above ground at a height no greater than 5 feet and with even support for the pipe barrel.
- G. Only nylon protected slings shall be used for handling the pipe. No hooks, chains or bare cables will be permitted.
- H. Gaskets shall be shipped in cartons and stored in a clean area, away from grease, oil, heat, direct sunlight and ozone producing electric motors.
- I. Jointing of ductile iron push on pipe and fittings shall be done in accordance with the printed recommendations of the manufacturer and as specified. The last 8 inches of the outside of the spigot end of pipe and the inside of the bell end of pipe shall be thoroughly cleaned. The joint surfaces and the gasket shall be painted with a lubricant just prior to making up the joint. The spigot end shall then be gently pushed home into the bell. The position of the gasket shall be checked to ensure that the joint has been properly made and is watertight. Care shall be taken not to exceed the manufacturer's recommended maximum deflection allowed for each joint.
1. Jointing Ductile Iron Pipe (Push-On Type): Push-on joints shall be made in strict accordance with the manufacturer's instructions. Pipe shall be laid with bell ends looking ahead. A rubber gasket shall be inserted in the groove of the bell end of the pipe, and the joint surfaces cleaned and lubricated. The plain end of the pipe to be entered shall then be inserted in alignment with the bell of the pipe to which it is to be joined, and pushed home with a jack or by other means. After joining the pipe, a metal feeler shall be used to make certain that the rubber gasket is correctly located.
 2. Jointing Mechanical Joint Fittings: Mechanical joints at valves, fittings, and where designated shall be installed in accordance with the "Notes on Method of Installation" under ANSI Specification A 21.11 and the instructions of the manufacturer. To assemble the joints in the field, the Contractor shall thoroughly clean the joint surfaces and rubber gasket with soapy water before tightening the bolts. Bolts shall be tight to the specified

torque. Under no condition shall extension wrenches or pipes over handles or ordinary ratchet wrenches be used to secure greater leverage.

- J. Installation and jointing of ductile iron pipe shall be in accordance with AWWA C600, Sections 9b and 9c, latest revision, as applicable.
- K. Ductile iron pipe installed within 5-feet of gas lines shall be fully encased with polyethylene material. Polyethylene shall be 8 millimeters thick and comply with AWWA C 105.

3.7 CLEANOUTS

- A. Install cleanouts and extensions from sewer pipe to grade as indicated on the Contract Drawings. Set cleanout frame and cover in concrete 18 by 18 by 6-inches deep, except where location is in bituminous or concrete paving. Set top of cleanout 1-inch above surrounding earth grade or flush with grade when installed in paving.

3.8 SEWER COUPLINGS

- A. Couplings which are factory manufactured shall be installed at all connections from existing pipe to proposed pipe unless the existing pipe is the same material as the proposed pipe and the bell and spigot end of the pipes to be connected are compatible and free from defects. All sewer couplings shall be installed in accordance with the manufacturer's recommendations for the types of pipe to be connected.

3.9 TAP CONNECTIONS

- A. Make connections to existing piping and underground structures so that finished work will conform as nearly as practicable to the requirements specified for new work. The contractor shall verify the location, size, invert, and type of existing pipes at all points of connection prior to make the connections.
- B. Make branch connections from side into existing piping by installing a wye or T-wyes, and couplings manufactured for use with the same type of pipe as indicated on the Contract Drawings. The Contractor shall install a 45° wye branch or 90° tee fittings in the sewer pipe at all locations where building sewer service pipe connections are shown on the Drawings. Connections of the sewer service pipes shall be made into the wye branches or tees by means of 45° bends. The connections shall be made thoroughly watertight and concrete shall be placed under each connection to bear on undisturbed earth and firmly support the connection.
- C. Protect existing piping and structures to prevent concrete or debris from entering while making tap connections. Remove debris, concrete, or other extraneous material that may accumulate.
- D. Connections into existing sewer facilities shall be performed in accordance with the requirements of the Town of Wakefield. The Contractor shall comply with all such requirements, including securing of all required permits and paying the costs thereof.

3.10 INSTALLATION OF PUMP SYSTEM

- A. General: Install all equipment in accordance with manufacturer's instructions.
- B. Wet Well and Valve Vault: Install precast pump chamber and precast valve vault on a compacted level foundation of structural fill a minimum 12 inches thick over the compacted

subgrade. Crushed stone may be substituted for structural fill if field conditions at the bottom of the excavation are wet. The chambers shall be set level and plumb.

- C. Equipment: Install all chamber equipment in accordance with manufacturer's instructions. Seal chamber penetration with modular, mechanical seals, consisting of rubber links shaped to continuously fill the annular space between the pipe and the wall openings.
- D. Force Main: Install force main as shown on the Contract Drawings. Lay piping at slopes that will not create high or low points between the valve vault and the receiving sewer manhole. Concrete thrust blocks shall be installed at all fittings and other locations as indicated on the Contract Drawings and as directed by the Engineer. Minimum bearing area shall be as shown on the Contract Drawings. Thrust blocks shall bear against undisturbed material, and shall be provided with wooden side forms. In the event that the use of thrust blocks is not practical, the Contractor shall provide an alternate method of joint restraint, at no additional cost, as approved and/or as directed by the Engineer.
- E. Testing: Provide the services of a manufacturer's trained technician to start-up and test the system. Pumps shall be throttled with the gate valves to create sufficient TDH to reduce discharge rate to 120 gallons per minute. The performance of the system for lead pump, lag pump, high water alarm, and alternation, and reset shall be demonstrated to the approval of the Engineer.

3.11 INSTALLATION OF IDENTIFICATION

- A. Install continuous plastic underground warning tape during back-filling of trench for underground sanitary sewerage system piping. Locate tape two-feet below finished grade, directly over piping.

3.12 BACKFILLING

- A. General: Conduct excavation and backfill operations for structure and pipe installations in accordance with Section 312000 – EARTH MOVING/Section, local requirements, and the contract documents.
- B. Initial backfill shall be placed evenly on both sides of the pipe to distribute the load and not to cause movement or deflection of the pipe.

3.13 FIELD QUALITY CONTROL

- A. Testing: Perform testing of completed piping in accordance with local authorities having jurisdiction and the following:
 - 1. Testing shall be witnessed by the Owner's Representative and the local authority.
 - 2. The test shall be by vacuum or by water exfiltration as described herein:
 - 3. Vacuum Testing of Precast Concrete Manholes
 - a. The vacuum test shall be conducted on each manhole in accordance with ASTM C1244. Test results will be judged by the length of time it takes for the applied vacuum to drop from 10 inches of mercury to 9 inches. If the time is less than that listed in Table 1 of ASTM C1244, the manhole will have failed the test. Test times from Table 1 are excerpted below.

TABLE 1

Minimum Test Times for Various Manhole Diameters

Depth (Feet)	Diameter (Inches)		
	48	60	72
	<u>Times (Seconds)</u>		
0-12	30	39	49
12-16	40	52	67
16-20	50	65	81
20-24	59	78	97
26-30	74	98	121

- b. If the manhole fails the initial test, the Contractor shall locate the leaks and make the proper repairs. Leaks may be filled with a wet slurry of accepted quick setting material. If the manhole should again fail the vacuum test, additional repairs shall be made, and the manhole water tested as specified below.
4. Water Exfiltration Testing of Precast Concrete Manholes
 - a. After the manhole has been assembled in place, all lifting holes shall be filled and pointed with an approved non-shrinking mortar. All pipes and other openings into the manhole shall be suitably plugged and the plugs braced to prevent flow out. The test shall be made prior to placing the shelf and invert. If the groundwater table has been allowed to rise above the bottom of the manhole, it shall be lowered for the duration of the test.
 - b. The manhole shall be filled with water to the top of the cone section. If the excavation has not been backfilled and observation indicates no visible leakage, that is, no water visibly moving down the surface of the manhole, the manhole may be considered to be satisfactorily water tight. If the test, as described above, is unsatisfactory as determined by the Owner's Representative and/or the Town of Wakefield Inspector or if the manhole excavation has been backfilled, the test shall be continued. A period of time may be permitted if the Contractor so wishes, to allow for absorption by the manhole. At the end of this period, the manhole shall be refilled to the top of the cone, if necessary, and a measuring time of at least 8 hours begun. At the end of the test period, the manhole shall be refilled to the top of the cone, measuring the volume of water added. This amount shall be extrapolated to a 24-hour loss rate and the leakage determined on the basis of depth. The leakage for each manhole shall not exceed one gallon per vertical foot for a 24-hour period. If the manhole fails this requirement, but the leakage does not exceed 3 gallons per vertical foot per day, repairs by approved methods may be made as required by the Owner's Representative and/or Town of Wakefield Inspector to bring the leakage within the allowable rate of one gallon per foot per day. Leakage due to a defective section or joint or exceeding the 3 gallons per vertical foot per day shall be cause for rejection of the manhole. It shall be the Contractor's responsibility to uncover the rejected manhole as necessary and to disassemble, reconstruct or replace it as required by the Owner's Representative. The manhole shall then be retested and, if satisfactory, interior joints shall be filled and pointed.
 - c. No adjustment in the leakage allowance will be made for unknown causes such as leaking plugs, absorption, etc. It shall be assumed that all loss of water during the test is a result of leaks through joints or through the concrete. Furthermore, the Contractor shall take any steps necessary to assure the Owner's Representative

and/or Town of Wakefield Inspector that the water table is below the bottom of the manhole throughout the test.

- d. If the groundwater table is above the highest joint in the manhole, and there is no leakage into the manhole, as determined by the Owner's Representative and/or the Town of Wakefield Inspector, such a test can serve to evaluate water-tightness of the manhole. However, if the Owner's Representative and/or the Town of Wakefield Inspector is not satisfied with the results, the Contractor shall lower the water table and carry out the test as described hereinbefore.
5. Leakage Testing of Gravity Sewer Piping and Fittings
- a. On completion of a section of sewer, including building connections, the Contractor shall install suitable bulkheads as required, dewater and test the sewer for leakage.
 - b. Unless otherwise approved, the section shall be tested using low-pressure air test procedures. If circumstances permit, the Owner's Representative and/or the Town of Wakefield Inspector may allow testing by infiltration or exfiltration in lieu of air testing.
 - c. The air test procedures shall conform to the Uni-Bell Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe, UNI-B-6. The starting air pressure for the test shall be 4 psig (greater than the average groundwater back pressure of any groundwater above the pipe, but not greater than 9.0 psig). The minimum duration permitted for the prescribed low-pressure air exfiltration pressure drop between two consecutive manholes shall not be less than provided in Table I or Table II of UNI-B-6. Note that UNI-B-6 suggests that use of the 0.5 psig pressure drop is more efficient since the time requirements are half of the 1.0 psig-pressure drop.
 - d. Using the air pressure test, if there has been no leakage (zero psig drop) after one hour of testing, the section undergoing test shall have passed.
 - e. If either infiltration or exfiltration testing is permitted by the Engineer, the test shall be conducted for at least 24 hours. The amount of infiltration or exfiltration shall not exceed 100 gallons per inch diameter per mile of sewer per 24 hours.
 - f. The infiltration test measures leakage into a section of sewer and may be used only where the groundwater level is one foot or more above the crown of the section of sewer pipe at its upper end and at least one foot above the top of building connections and chimneys. For making the infiltration tests, underdrains, if used, shall be plugged and other groundwater drainage shall be stopped to permit the groundwater to return to its normal level insofar as practicable. Allowances shall be made for water that may enter the sewer through pipe connections and inlets during the infiltration test.
 - g. Where the groundwater level is less than 1 foot above the top of the pipe at its upper end, the exfiltration test may be used. The sewers shall be subjected to an internal pressure by plugging the pipe at the lower end and then filling the pipelines and manholes with clean water to a height of 2 feet above the highest point in the system to be tested, including main pipeline, service connections, and chimneys. When slopes between manholes are steep, the Contractor shall ensure that this test can be accomplished without danger of forcing stoppers from wye or tee branches.
 - h. The rate of exfiltration from the sewers shall be determined by measuring the amount of water required to maintain the water level at the elevation established at the beginning of the test

- i. The Contractor shall construct such weirs or other means of measurements as may be required, shall furnish water, and shall do all necessary pumping to enable the test to be properly made.
 - j. The Contractor shall be responsible for the satisfactory water-tightness of the entire section of sewer. Should the sections under test fail to meet the requirements, the Contractor shall do all work of locating and repairing leaks and retesting as the Engineer may require without additional compensation. A plan of the method of repairing any leaks that are found shall be submitted to the Engineer for review.
6. Pressure sewers (force mains) shall be hydro-tested to a pressure of 1.5 times the working pressure]. Testing procedure shall be as specified in AWWA C600-99 and C900-97 (or latest revisions)-Standard Hydrostatic Test Method of (CIP/DIP and PVC) Sewer Force Mains, further as modified by the required test time shall be one (1) hours, the required pressure shall be 1.5 times the working pressure of the pipe and the allowable leakage shall not exceed "A" in the following formula:

$$A=DL(P^{0.5})/133,200$$

Where: A=The allowable leakage in gallons

D=The Diameter of pipe in inches being tested

L=The Length of pipe in feet being tested

P=The Pressure in pounds per square inch utilized for the test

7. Pipe Deflection Measurement
 - a. In accordance with ASTM D3034, no less than 30 days after completion of the PVC sewer pipe installation, the Contractor shall test the pipeline for deflection using a "go/no go" deflection mandrel having a minimum of nine evenly spaced arms or prongs. The "go/no go" gauge shall be hand pulled through all sections of the pipeline by the Contractor. The Contractor shall submit drawings of the "go/no go" gauge to the Owner's Representative and/or the Town of Wakefield Inspector for approval prior to testing. Complete dimensions of the gauge for each diameter of pipe to be tested shall be in accordance with ASTM D3034.
 - b. Any section of pipe found to exceed 7.5 percent deflection shall be deemed a failed pipe and shall be excavated and replaced by the Contractor at his own expense.
8. Video Inspections: Seven days after the completion of the backfilling of each section of new pipe, as defined as a length of pipe between two manholes, the Contractor shall provide a televised inspection of the pipe to be submitted to the Designer. The Owner's Representative shall be present during the recording. The recording shall be in DVD color format with audio and shall show a clear picture of the inside of the new pipe. If the Designer determines that the DVD is unacceptable for review the contractor shall re-televiser the line until an acceptable DVD has been submitted. In the event that the pipe is not acceptable for any reason relating to the proper construction of the pipe according to these specifications, the Contractor will be responsible to re-excavate and repair the defects to the satisfaction of the Designer at no additional cost.

- B. Cleaning: Clear interior of piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed.
 - 1. In large, accessible piping, brushes and brooms may be used for cleaning.
 - 2. Place watertight plugs in ends of uncompleted pipe at end of day or whenever work stops. If water is in the trench when work is resumed, the plug shall not be removed until the trench has been dewatered and all danger of water entering the pipe eliminated.
 - 3. Flush piping between manholes to remove collected debris.
- C. Interior Inspection: Inspect piping to determine whether line displacement or other damage has occurred.
 - 1. Make inspections after pipe between manholes has been installed and approximately 2 feet of backfill is in place, and again at completion of project.
 - 2. If inspection indicates poor alignment, debris, displaced pipe, infiltration or other defects, the Contractor shall correct such defects and reinspect.
- D. Prior to acceptance of the sanitary sewerage system, the Contractor shall submit the following to the Architect and to the local authority:
 - 1. System As-Built Plan stamped by a Professional Land Surveyor or Engineer Registered in the Commonwealth of Massachusetts.
 - 2. Video inspection DVDs and report: The report shall document the observations of the video inspections.
 - 3. Deflection test report: The report shall fully describe the test procedures and list the test results. The report shall be signed by the Contractor's superintendent.
 - 4. Leakage test report: The report shall fully describe the test procedures and list the test results. The report shall be signed by the Contractor's superintendent.

3.14 FINAL INSPECTION

- A. Final inspection and acceptance of the sanitary sewer system shall be made by the Owner's Representative and the utility owner having jurisdiction of the particular system.
- B. Prior to placing the systems in service, all components shall be inspected, with the Owner's Representative present, to ensure that no debris or other contaminants are present. If necessary, the Contractor shall clean the structures and flush piping.
- C. The Contractor is responsible for coordinating and scheduling the inspection of the work by local jurisdictional authorities. No additional payment will be made for inspections and permits required in the performance of the work.

END OF SECTION 333000

SECTION 334000
STORM DRAINAGE UTILITIES

PART 1 – GENERAL

1.1 GENERAL PROVISIONS

- A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all SECTIONS within DIVISION 1 – GENERAL REQUIREMENTS, which are hereby made a part of this section of Specifications.

1.2 DESCRIPTION OF WORK

- A. Work Included: Provide labor, materials, and equipment necessary to construct the storm drainage system complete, including connections to existing structures and testing, as indicated on the Drawings and as specified.
- B. Unless otherwise indicated on the Drawings, building drain service lines shall be installed from a point 10 feet outside the building foundation walls to the point of disposal.
- C. Related Work: The following items are noted and included in this Section and will be performed under the designated sections:
 - 1. Section 312000 – EARTH MOVING for soil materials, excavating, backfilling, and site grading and removal of site utilities.
 - 2. Section 221400 – FACILITY STORM DRAINAGE for building storm drainage piping.

1.3 SUBMITTALS

- A. Refer to Section 013300 – SUBMITTAL PROCEDURES, for submittal provisions and procedures.
 - 1. Product Data: Submit manufacturer's technical product data and installation instructions for storm drain system materials and products.
 - 2. Submit descriptive literature for piping, fittings, couplings, and appurtenances showing pipe dimensions, pipe and joint materials and dimensions, and other details for each class or type of pipe or product to be furnished for this contract. All pipe furnished under the contract shall be manufactured in accordance with these Specifications.
 - 3. Submit shop drawings for storm drain systems, showing piping and manhole materials and sizes.
 - 4. Submit shop drawings of complete layout of detention/retention structures, including all fittings and appurtenances.
 - 5. The precast concrete structure shop drawing submittals for the manholes, catch basins, vaults, and tanks shall contain erection drawings showing connections, cast-in items, waterproofing details, lifting hooks, and production drawings showing elevations, sections, and details indicating sizes and quantities of reinforcement.
 - 6. Submit shop drawings for structure frames, grates, and covers.
 - 7. Filter fabric: Submit the manufacturer's information.
 - 8. For trench drains submit shop drawings showing a schematic plan of the entire trench drain system, listing all parts being provided with exact centerline dimensions suitable for installation. Copies of the manufacturer's recommended method of installation and assembly shall be submitted for review.
 - 9. For water quality structures and stormwater quality filter treatment structures submit shop drawings for the structure and performance. Shop drawings shall detail the

structures precast concrete components, inserts, and castings. Where an external bypass is required, the manufacturer shall provide calculations and designs for all structures, piping and any other required material applicable to the proper functioning of the system, stamped by a Professional Engineer.

10. The Contractor shall submit buoyancy calculations for storm drainage structures assuming groundwater is one (1) foot below finish grade. If buoyancy is an issue the structure(s) shall be modified to prevent uplift. All buoyancy calculations and precast concrete structure designs shall be prepared and sealed by a professional Civil Engineer licensed in the state of Massachusetts.
11. Prior to the acceptance of the storm drainage system, the Contractor shall submit to the Engineer, for review and approval, As-Built Drawings that indicate the true measurement and location, horizontal and vertical, of all new construction. As-Built drawings shall be stamped and signed by a Massachusetts Licensed Land Surveyor or Licensed Professional Engineer. The as-built plans shall also be submitted electronically as an AutoCAD drawing file (release 2010 or higher).
12. Prior to acceptance of the storm drainage system, the Contractor shall submit the results of the pipe deflection measurements and the video inspection reports.

1.4 REFERENCE STANDARDS

- A. The following standards are applicable to the work of this Section to the extent referenced herein:
 1. ASTM: American Society for Testing and Materials.
 2. ANSI: American National Standards Institute.
 3. AASHTO: American Association of State Highway and Transportation Officials.
 4. Reference is made herein to the Commonwealth of Massachusetts, Department of Transportation (MassDOT), Formerly Massachusetts Highway Department (MHD) Standard Specifications for Highways and Bridges, latest edition, hereinafter referred to as the "Standard Specifications". All references to method of measurement, basis of payment, and payment items in the "Standard Specifications" are hereby deleted. References made to particular sections or paragraphs in the "Standard Specifications" shall include all related articles mentioned therein.
 5. MassDOT Construction Standards, latest Edition with amendments, hereinafter referred to as the "Construction Standards."

1.5 EXAMINATION OF SITE AND DOCUMENTS

- A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation of the site.
- B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.6 QUALITY ASSURANCE

- A. Environmental Compliance: Comply with applicable portions of local environmental agency regulations pertaining to storm drain systems.

- B. Utility Compliance: Comply with the Town of Wakefield regulations, standards, and guidelines pertaining to storm drainage system installation and inspections.
- C. Plumbing Code Compliance: Comply with applicable portions of Massachusetts Plumbing Code and National Standard Plumbing Code, latest editions, pertaining to selection and installation of storm drain system's materials and products.
- D. Manufacturer's Qualifications: Firms regularly engaged in manufacturing of storm drain system's products of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than five years.
- E. Installer's Qualifications: Firms with at least three years of successful installation experience on projects with storm drain work similar to that required for the project.

1.7 PROJECT CONDITIONS

- A. Site Information: Perform site inspection and survey, research utility records, and verify existing utility locations and elevations. Verify that storm drainage system structures and piping may be installed in compliance with Contract Drawings and referenced standards.
- B. Interruption of Existing Storm Drainage System: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to the requirements indicated:
 - 1. Notify Architect no fewer than two days in advance of proposed interruption of service.
 - 2. Do not proceed with interruption of service without Architect's written permission.

1.8 SEQUENCING AND SCHEDULING

- A. Coordinate with interior building storm drain system piping.
- B. Coordinate with other utility work.
- C. The Contractor is responsible for developing a sequence of work to maintain existing services in operation until the new services are operational.
- D. The Contractor is responsible for coordinating and scheduling the inspection of the work by the jurisdictional authority. All permits and inspection costs and fees shall be included in the bid prices and no additional costs will be paid to the Contractor.

PART 2 – PRODUCTS

2.1 PRECAST CONCRETE VAULTS AND TANKS

- A. The precast reinforced concrete vault and tank structures shall be designed by a Massachusetts Registered Professional Engineer employed by the Contractor, in accordance with the applicable sections of the following references:
 - 1. Commonwealth of Massachusetts State Building Code, latest edition.
 - 2. American Concrete Institute, ACI 318 "Building Code Requirements for Reinforced Concrete."
 - 3. AASHTO, "Standard Specifications for Highway Bridges."
 - 4. Precast Concrete Institute, "Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products, MNL-116."
- B. The structures shall be designed for the following loads and possible combinations thereof:

1. Lateral soil pressure = 60 PCF (H), where H is the height from grade, as shown on the Contract Drawings, to the point of the structure being considered.
 2. Soil weight shall be assumed to be 120 PCF.
 3. AASHTO HS-20-44 loading.
 4. Weight of precast concrete structure.
 5. Initial handling and erection loadings, including design of galvanized lifting hooks using a safety factor = 4.0.
- C. Investigate buoyancy and soil bearing considerations assuming the groundwater elevation is one-foot below the ground surface.
- D. Concrete shall have a minimum 28-day compressive strength of 5,000 psi using Type II or III Portland cement with 8% maximum content of tricalcium aluminate, ASTM C150. A "normal dosage" of air-entraining agent shall be added to the concrete during the mixing cycle. Reinforcement shall be deformed billet-steel ASTM A615 or 7-wire strand ASTM A416, Grade 270 (if prestressed).
- E. Dimensions and opening sizes and locations shall be as indicated on the Contract Drawings.
- F. Pipe Connections: Vault and tank structures shall have pipe openings to accept the type of pipe specified. Pipe opening shall be minimum size required to receive the pipe and shall be accurately set to conform to the required line and grade. Drainage pipe shall be joined to the wall of the concrete structure with flexible pipe sleeves as indicated on the drawings. Flexible pipe sleeves shall be cast in the walls of the structure during the manufacturing process. Flexible pipe sleeves shall be NPC Kor-N-Seal Pipe-to-Manhole Connector as manufactured by Trelleborg Pipe Seals Milford, Inc., Milford, NH; Z-Lok as manufactured by A-Lok Products, Inc., Tullytown, PA; Tylox CIB Series Cast-In Boot Connector as manufactured by Hamilton Kent, Winchester, TN; or approved equal.
- G. Waterproofing: The exterior surfaces of precast structures shall be given two heavy coats of waterproofing concrete sealer. The material shall be Aqua-Safe Concrete Sealer as manufactured by Bay Oil Company, Chicopee, MA; Bitumastic 300M as manufactured by Carboline Company, St. Louis, MO; Sonoshield HLM 5000 as manufactured by BASF Corporation Building Systems, Shakopee, MN; ConSeal CS-1800 as manufactured by Concrete Sealants, Inc., Tipp City, OH; or acceptable equivalent products. The waterproofing material shall be applied by brush or spray and in accordance with the instructions of the manufacturer. Time shall be allowed between coats to permit sufficient drying so that the application of the second coat has no effect on the first coat.
- H. Storm Drainage Brick Masonry: Bricks shall be sound, hard, uniformly burned, regular, and uniform in shape and size. Underburned or salmon brick shall not be acceptable. Only whole brick shall be used.
1. Bricks for raising manhole and catch basin frames to finished grade shall conform to ASTM C32, Grade MS.
 2. Mortar shall be in conformance with ASTM C270, Type M. The mortar shall be composed of one-part Portland cement, 3-1/2 parts sand, and ¼ parts hydrated lime, by volume. Portland cement shall be ASTM C150, Type II; hydrated lime shall be Type S conforming to ASTM D207.
 3. Sand shall be washed, cleaned, screened, well-graded with all particles passing a No. 4 sieve, and conform to ASTM C33.

- A. General: Provide precast reinforced concrete structures as indicated and complying with ASTM C 478.
- B. Manhole Top: Precast concrete, of concentric cone, eccentric cone, or flat slab top type, as indicated in the Contract Drawings. Tops shall be designed to meet H20 loadings.
- C. Base and Riser Sections: Precast concrete, with base riser section with integral floor. Diameter, base and riser thicknesses shall be as indicated on the Contract Drawings.
- D. Cement: Type II.
- E. Concrete strength: 4,000 psi minimum.
- F. Precast concrete sections shall have tongue and groove joints.
- G. Horizontal Joints: Joints between sections of concrete structures shall be sealed with a flexible, watertight joint, made with preformed butyl rubber joint sealant conforming to ASTM C990 or with a rubber gasket joint conforming to ASTM C443. Sealants and/or gaskets shall be installed in accordance with the manufacturer's written instructions.
- H. Manhole Steps: Steps for manholes shall be non-skid raised edge-front steel reinforced polypropylene plastic type with at least 13-inch-wide stepping surface. Steps shall meet the requirements of ASTM C-478 and AASHTO M-199. Steel shall be 1/2-inch grade 60 conforming to ASTM A615 encapsulated with molded copolymer polypropylene. The polypropylene shall conform to ASTM D-4101. Rungs shall protrude no more than 6 inches from the wall. The portion of the legs to be embedded in the precast section shall have fins and be tapered to ensure a secure bond. Steps shall start a foot above the shelf of the manhole floor and continued twelve inches on center spacing up through the completed height of the unit. The steps shall finish no lower than twenty-four (24)-inches below the rim elevation. Placement into precast walls shall be by a method recommended by the supplier of the precast manhole sections. Steps shall be installed per the manufacturer's specifications.
- I. Pipe Connections: Drainage structures shall have plain beveled openings to accept the type of pipe specified. Pipe openings shall be minimum size required to receive the pipe and shall be accurately set to conform to the required line and grade. Drain pipe shall be joined to the wall of the concrete manhole or catch basin with non-shrink grout or flexible manhole sleeve as indicated on the drawings. Grout mixture shall follow instructions provided by manufacturer. Flexible manhole sleeves shall be cast in the walls of the manholes during the manufacturing process. Flexible manhole sleeves shall be NPC Kor-N-Seal Pipe-to-Manhole Connector as manufactured by Trelleborg Pipe Seals Milford, Inc., Milford, NH; Z-Lok as manufactured by A-Lok Products, Inc., Tullytown, PA; Tylox CIB Series Cast-In Boot Connector as manufactured by Hamilton Kent, Winchester, TN; or approved equal.
- J. Storm Drainage Brick Masonry: Bricks shall be sound, hard, uniformly burned, regular, and uniform in shape and size. Underburned or salmon brick shall not be acceptable. Only whole brick shall be used.
 - 1. Bricks for raising manhole and catch basin frames to finished grade shall conform to ASTM C32, Grade MS.
 - 2. Mortar shall be in conformance with ASTM C270, Type M. The mortar shall be composed of one-part Portland cement, 3-1/2 parts sand, and 1/4 parts hydrated lime, by volume. Portland cement shall be ASTM C150, Type II; hydrated lime shall be Type S conforming to ASTM D207.

3. Sand shall be washed, cleaned, screened, well-graded with all particles passing a No. 4 sieve, and conform to ASTM C33.
- K. Inverts in drain manholes shall be constructed of cement concrete shaped to conform accurately to size of the adjoining pipe. Side inverts and main inverts where the direction changes shall be laid out in smooth curves of the longest possible radius which is tangent, within the manhole, to the centerline of the adjoining pipe lines.
- L. For all manhole depths greater than 10 feet, the inside diameter of the manholes shall be at least 5'-0".
- M. Safety landings will be installed inside manholes greater than 16-feet in depth.
- N. When installing manholes on existing lines and when flows cannot be diverted, drop-over manholes shall be used. Drop-over manholes shall be precast with opening cast in the sidewalls of sufficient size to fit over the existing line(s) to remain in service. Drop-over manholes shall be set on a precast or cast-in-place concrete base slab. Drop-over manholes shall be manufactured to the same requirements and dimensions as standard manholes.

2.3 MANHOLE FRAMES AND COVERS

- A. Frames and covers shall be of cast iron conforming to the requirements of ASTM A48, Class No. 30 and shall be manufactured by General Foundries Inc., North Brunswick, New Jersey; East Jordan Iron Works (formerly LeBaron Foundry, Inc.), East Jordan, Michigan; Neenah Foundry Company, Neenah, Wisconsin; or approved equal. Manhole covers shall be machined to fit securely and evenly on the frame. Frames and covers shall be designed to accept H20 loads, have a diamond surface finish, and frame height of 6 to 9-inches. Covers shall be equal to Item Numbers 12665 and 12685 (6" and 8-1/8" frame heights, respectively) as manufactured by General Foundries Inc. Catalog numbers are provided to establish a standard of quality and configuration of castings. Covers shall bear the word "DRAIN" in 3-inch-high letters.

2.4 CATCH BASIN FRAMES AND GRATES

- A. Catch basin grates located at low points shall consist of a 24-inch square grate with a minimum frame height of 8 inches unless otherwise noted on the drawings. Frames and grates shall be of cast iron and designed to accept H20 loads. Catch Basin Frames and Grates shall be manufactured by General Foundries Inc., North Brunswick, New Jersey; East Jordan Iron Works (formerly LeBaron Foundry, Inc.), East Jordan, Michigan; Neenah Foundry Company, Neenah, Wisconsin; or approved equal. Single frames and grates shall be equal to Item Numbers 22444-SQH, 22464-SQH, and 22484-SQH (4", 6", and 8" frame heights, respectively) as manufactured by General Foundries Inc. ADA Compliant frames and grates shall be equal to Item Numbers 22444-ADA, 22464-ADA, and 22484-ADA (4", 6", and 8" frame heights, respectively) as manufactured by General Foundries Inc. Double frames and grates shall be equal to Item Numbers 24844-SQH, 24864-SQH, and 24884-SQH (4", 6", and 8" frame heights, respectively) as manufactured by General Foundries Inc. Four and three-flange frames shall be provided as required. Catalog numbers are provided to establish a standard of quality and configuration of castings.
- B. Catch basin cascade frames and grates shall consist of a 24-inch square grate with a minimum frame height of 8 inches unless otherwise noted on the drawings. Frames and grates shall be of cast iron and designed to accept H20 loads. Cascade frames and grates shall be manufactured by General Foundries Inc., North Brunswick, New Jersey; East Jordan Iron Works (formerly LeBaron Foundry, Inc.), East Jordan, Michigan; Neenah Foundry Company, Neenah, Wisconsin; or approved equal. Cascade frames and grates shall be equal to Item Numbers 22444-CAS, 22464-CAS, and 22484-CAS (4", 6", and 8" frame

heights, respectively) as manufactured by General Foundries Inc. Four and three-flange frames shall be provided as required. Catalog numbers are provided to establish a standard of quality and configuration of castings.

2.5 CATCH BASIN HOODS

- A. All catch basins shall have hoods installed over the outlet pipe. Hoods shall be cast iron removable or hinged traps that fit over the catch basin outlet pipe. Traps shall be approximately 19-inches wide by 18-inches high and extend 11-inches from the wall of the structure. Catch Basin Hoods shall be manufactured by General Foundries Inc., North Brunswick, New Jersey; East Jordan Iron Works (formerly LeBaron Foundry, Inc.), East Jordan, Michigan; Neenah Foundry Company, Neenah, Wisconsin; or approved equal. Hoods shall be equal to Item Number MATRP as manufactured by General Foundries Inc. Catalog numbers are provided to establish a standard of quality and configuration of castings.

2.6 AREA DRAIN

- A. Area drains required for this contract shall be manufactured from PVC pipe stock, utilizing a thermo-molding process to reform the pipe stock to the specified configuration. The drainage pipe connection stubs shall be manufactured from PVC pipe stock and formed to provide a watertight connection with the specified pipe system. This joint tightness shall conform to ASTM D3212 for joints for drain and sewer plastic pipe using flexible elastomeric seals conforming to ASTM F477. The pipe bell spigot shall be joined to the main body of the area drain. A PVC cap shall be installed at the bottom of the area drain sump. The raw material used to manufacture the pipe stock that is used to manufacture the main body and pipe stubs of the surface drainage inlets shall conform to ASTM D1784 cell class 12454. Area drains shall be manufactured by Nyloplast or approved equal.
- B. Grates and frames furnished for all area drainage shall be ductile iron for sizes 8", 10", 12", 15", 18" and 24" and shall be made specifically for each basin so as to provide a round bottom flange that closely matches the diameter of the surface drainage inlet. Grates for area drains shall be capable of supporting H-20-wheel loading for vehicular traffic areas or H-10 loading for pedestrian traffic areas unless otherwise noted. 12" and 15" square grates shall be hinged to the frame using pins. Metal used in the manufacture of the castings shall conform to ASTM A536 grade 70-50-05 for ductile iron. Grates shall be provided painted black. Grates in walkways shall meet ADA requirements. Grates in planting beds shall be domed grates. The grates furnished for area drains bioretention areas shall be 24" in diameter. All area drain grates should include a locking device. Area drain grates shall be manufactured by Nyloplast or approved equal.

2.7 INLINE DRAINS

- A. The inline drain required for this contract shall be manufactured from PVC pipe stock, utilizing a thermos-molding process to reform the pipe stock to the furnished configuration. The drainage pipe connection stubs shall be manufactured from PVC pipe stock and formed to provide a watertight connection with the specified pipe system. This joint tightness shall conform to ASTM D3212 for joints for drain and sewer plastic pipe using flexible elastomeric seals. The flexible elastomeric seals shall conform to ASTM F477. The pipe bell spigot shall be joined to the inline drain body by use of a swage mechanical joint. The ram material used to manufacture the pipe stock that is used to manufacture the inline drain body and pipe stubs of the surface drainage inlets shall conform to ASTM D1784 cell class 12454.
- B. The grates furnished for all surface drainage inlets shall be ductile iron grates for sizes 8", 10", 12", 15", 18", and 30" shall be made specifically for each fitting so as to provide a round bottom flange that closely matches the diameter of the surface drainage inlet. Grates for inline drains shall be capable of supporting H-20-wheel loading for traffic areas or H-10

loading for pedestrian areas. 12" and 15" square grates will be hinged to the frame using pins. Metal used in the manufacture of the castings shall conform to ASTM A536 grade 70-50-05 for ductile iron. Grates shall be provided painted black.

2.8 MANUFACTURED TRENCH DRAINS

- A. Trench drains shall be a pre-engineered, manufactured system that conforms to the design loading requirements of AASHTO H-20 and HS-20 (minimum) with the following minimum requirements:
1. Channels shall be manufactured from polyester resin polymer concrete with an integrally cast-in ductile iron edge rail. Each edge rail shall be at least ¼" thick.
 2. The polymer concrete shall be frost proof, dilute acid and alkali resistant, and salt proof (B117 Salt Spray Test Compliant) with the minimum properties as follows:
 - a. Compressive Strength: 14,000 psi
 - b. Flexural Strength: 4,000 psi
 - c. Tensile Strength: 1,500 psi
 - d. Water Absorption: 0.07%
 3. The system shall be 12" nominal internal width with a 14.2" overall width and a built-in slope of 0.5%. Channel invert shall have a partial radius in the trench bottom. All channels shall be interlocking with a male/female joint.
 4. Trench drain grates shall be slotted ductile iron conforming to ASTM 536-84, Grade 65-45-12. After removal of grates, there shall be uninterrupted access to the trench to aid maintenance.
 5. Units shall have horizontal cast in anchoring keys on the outside wall to ensure maximum mechanical bond to the surrounding bedding material and pavement surface.
 6. The trench drain shall have a locking device that directly connects the grate to the frame.
 7. Channel shall be designed to withstand loading to Load Class F as outlined by EN 1433. Grate type shall be appropriate to meet the system load class specified.
 8. Trench drain system shall be installed in strict accordance with manufacturer's installation instructions, recommendations, and shop drawings.

2.9 WATER QUALITY STRUCTURE

- A. The water quality drainage structure models indicated on the Contract Drawings are Stormceptor® as manufactured by the Stormceptor Corporation, Rockville, MD. Equivalent structures include Vortechs as manufactured by Vortech, Inc. of Portland, ME, and Downstream Defender as manufactured by Hydro International of Portland, ME. Other acceptable equivalent manufactured devices may be used if following requirements are met. Prior to acceptance, the contractor shall receive written approval for use of said substitution from the Town of Wakefield Conservation Commission and/or their authorized representatives.
- B. The water quality structure shall have a proven laboratory test record of having the capability to remove a minimum of 80% of the sediment load from the low-flow storm conditions from the total catchment area of the drainage system. Laboratory testing methods shall conform to the "Technology Acceptance Reciprocity Partnership" (TARP) Tier II protocol or other acceptable equivalent method and shall have the capability of removing clay and silt size particles.
- C. The available water quality structure laboratory performance documentation shall achieve a grade of "2" or better as rated through the "Massachusetts Stormwater Evaluation Project" (MAStep).

- D. The water quality structure shall be installed underground as part of the stormwater system.
- E. The structure shall be constructed of precast concrete components.
- F. Precast Concrete Sections: All precast concrete components shall be designed and manufactured to a minimum live load of AASHTO HS-20 truck loading.
- G. Horizontal Joints: Joints between sections of concrete structures shall be sealed with a flexible, watertight joint, made with preformed butyl rubber joint sealant conforming to ASTM C990 or with a rubber gasket joint conforming to ASTM C443. Sealants and/or gaskets shall be installed in accordance with the manufacturer's written instructions.
- H. Frame and Cover: The frame and cover shall clearly indicate with lettering the unit's name cast into the cover to allow for easy identification in the field.
- I. Concrete: Precast concrete components shall meet the requirements of ASTM C478.
- J. Fiberglass: The fiberglass portion of the water treatment structure shall be constructed in accordance with ASTM D409, Contact Molded Glass Fiber Reinforced Chemical Resistant Tanks. The internal fiberglass insert shall be bolted and sealed watertight inside the reinforced concrete component.
- K. The water quality structure shall be vertically oriented with easy access to facilitate maintenance.
- L. The first 16 inches of oil storage should be lined with fiberglass or other coating acceptable to the Engineer to provide double-wall containment of any hydrocarbon-based material.
- M. Water quality structure shall be equipped with high flow bypass that shall be physically separated from the separation area to prevent mixing.
- N. The structure shall be maintainable from the surface via access points without requiring entry into the structure.
- O. The structure shall be designed to prevent the formation of secondary eddy currents or scour conditions.
- P. The structure shall be able to be installed to the invert elevations of the drainage system as detailed on the Contract Drawings.
- Q. The water quality structure shall be capable of containing floatable substances such as oil and gasoline within the structure during normal operation as well as periods of service and repair. Floatables containment shall be achieved without the use of floatable additives.
- R. The water quality structure shall not be compromised by backwater conditions i.e., trapped pollutants should not be resuspended and scoured from the interceptor during backwater conditions.
- S. Calculations stamped by a Professional Engineer shall be supplied to demonstrate that the water quality structures will accept the design flow rates without causing a backwater condition.
- T. Inspection: All precast concrete sections shall be inspected to ensure that dimensions, appearance, and quality of the product meet the requirements of ASTM C478.

- A. General: Provide pipes of the following materials of class indicated. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.
1. Ductile iron pipe shall be that of a manufacturer who can demonstrate at least five years of successful experience in manufacturing ductile iron pipe. The pipe shall be equipped with push on type, restrained joint, or mechanical joints, as required.
 2. All ductile iron drain pipe shall conform to American Water Works Association (AWWA) C150 and AWWA C151.
 3. The ductile iron pipe shall be Class 52 and furnished in minimum nominal 18-foot lengths, with Push-on as manufactured by U.S. Pipe and Foundry Company, Atlantic States Cast Iron Pipe Co., Clow Corporation, or approved equal with gaskets conforming to AWWA C111 "Rubber Gasket Joints".
 4. Ductile iron drain pipe shall be cement-mortar lined and the pipe exterior asphalt seal coated in accordance with AWWA C104.
 5. The pipe shall be furnished along with necessary materials and equipment recommended by the manufacturer for use in joining pipe lengths and fittings.
 6. Fittings shall be ASTM A-536 ductile iron with mechanical joint fittings. All fittings 3 inch through 48 inches in diameter shall meet or exceed the requirements of AWWA C110. Compact fittings shall be ductile iron meeting or exceeding the requirements of AWWA C153. Fittings shall have the same lining and coating as the pipe specified above. All fittings shall be marked with the weight and shall have distinctly cast upon them the pressure rating, the manufacturer's identification, nominal diameter of openings and the number of degrees or fraction of the circle on all bends. All fittings 4 through 24 inches shall be Class 350. All fittings greater than 24 inches shall be as specified above except they shall be Class 250. Compact fittings shall only be used in sizes 4 through 24 inches. Fittings shall conform to the weights, excluding accessories, and dimension shown in the latest edition of the Handbook of Ductile Iron Pipe and come complete with all joint accessories as required. All accessories (gland gaskets, T-bolts, and nuts) shall be in accordance with AWWA C111. All mechanical joint bolts (T-bolts) shall be Cor-Ten or equal.
 7. Contractor shall provide all adapters and fittings such as transition couplings, as determined in the field, necessary to complete all cross connections, whether or not specifically stated in the Contract Drawings and Specifications.
 8. All pipes shall be marked with the class, thickness designation, and initials of the manufacturer.
 9. If required the manufacturer shall supply the Engineer with certificates of compliance with these Specifications and certification that each piece of ductile iron pipe has been tested at the foundry with the Ball Impression Test, Ring Bending, or equal.
 10. Pipe for use with sleeve-type couplings shall be as specified except that the ends shall be plain (without bells or beads). The ends shall be cast or machined at right angles to the axis.
- B. INSPECTION, TESTS, AND ACCEPTANCE FOR DUCTILE IRON PIPE
1. All pipe delivered to the job site shall be accompanied by test reports certifying that the pipe and fittings conform to "AWWA Standard for Ductile Iron Pipe, for Water and Other Liquids" (AWWA H3) and (AWWA C151).

2. All tests shall be made in accordance with the methods prescribed by the above mentioned AWWA Standards, and the acceptance or rejection shall be based on the test results.
3. Pipe which does not conform to the requirements of this contract shall be immediately removed and replaced by the Contractor.
4. All ductile iron pipe to be installed under this Contract may be inspected at the foundry for compliance with these Specifications by an independent testing laboratory selected by the Owner. The Contractor shall require the manufacturer's cooperation in these inspections. The cost of foundry inspection of all pipe approved for this Contract, plus the cost of the inspection of a reasonable amount of disapproved pipe, will be borne by the Owner.

C. SLEEVE COUPLINGS FOR DUCTILE IRON PIPE

1. Sleeve couplings and accessories shall be pressure rated at least equal to that of the pipe. Couplings shall be cast iron and shall be Dresser Style 53 or 153, Rockwell Style 441, Baker Series 4245 or acceptable equivalent product. The couplings shall be provided with Cor-Ten bolts and nuts or approved equal.
2. After assembly, all exterior surfaces including the bolts and nuts shall be thoroughly coated with two coats of heavy-duty protective coating. The interior of the coupling shall be epoxy coated. Coating shall be a minimum of 10 mils. and a maximum of 20 mils. dry film thickness thermosetting epoxy.

2.11 HUB AND SPIGOT CAST IRON SOIL PIPE AND FITTINGS

- A. Hub and Spigot Cast Iron pipe and fittings shall be manufactured from gray cast iron and shall conform to ASTM A74. Joints shall be made using a compression gasket manufactured from an elastomer meeting the requirements of ASTM C564. Installation shall comply with manufacturer's recommendations and applicable code requirements.

2.12 PVC DRAINAGE PIPE

- A. General: Provide pipes of the following materials of class indicated. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.
- B. PVC (Polyvinyl Chloride) Gravity Sewer Pipe and Fittings: ASTM D3034, SDR 35, for elastomeric gasket joints. Pipe 18 to 36 inches in diameter shall conform to ASTM F679, T-1 heavy wall. The pipe shall have a Standard Dimension Ratio (SDR) of 35 and a pipe stiffness of 46 psi.
- C. Joints: PVC pipe shall have an integral wall bell and spigot push-on joint with elastomeric gaskets secured in place in the bell of the pipe. The bell shall consist of an integral wall section with solid cross section elastomeric gasket, factory assembled, securely locked in place to prevent displacement during assembly. Pipe joints shall conform to ASTM D3212 and elastomeric gaskets shall conform to ASTM F477.
- D. Spigot pipe ends shall be supplied with bevels from the manufacturer to ensure proper insertion. Each spigot end shall have an "assembly stripe" imprinted thereon to which the bell end of the mated pipe will extend upon proper joining of the two pipes.
- E. PVC gravity sewer fittings and accessories shall be as manufactured and furnished by the pipe supplier or approved equal and have bell and spigot configurations compatible with that of the pipe.

- A. General: Provide pipes of the following materials of class indicated. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.
1. Corrugated polyethylene pipe shall have an interior surface that is smooth and even, free from roughness, projections, indentations, offsets, or irregularities of any kind.
 - a. Pipe shall conform to AASHTO M252, Type S for 4- through 10-inch diameter pipes.
 - b. Pipe shall conform to AASHTO M294, Type S or ASTM F2306 for 12- through 60-inch diameter pipes.
 - c. Fittings shall conform to AASHTO M252, AASHTO M294 or ASTM F2306. Bell and spigot connections shall utilize a spun-on or welded bell and valley or saddle gasket meeting the watertight joint performance requirements of AASHTO M252, AASHTO M294 or ASTM F2306.
 2. Pipe and fittings shall be high-density polyethylene meeting the requirements of ASTM D3350.
 3. Pipe units shall have a minimum laying length of 20-feet except as otherwise indicated or allowed by the Engineer.
 4. Pipe shall be installed with a minimum 12-inch cover for AASHTO H-20 loading.
- B. JOINTS ON CORRUGATED POLYETHYLENE PIPE
1. The pipe and fitting joints shall be bell-and spigot with watertight gaskets in accordance with the requirements of ASTM D3212.
 2. Gaskets shall meet the requirements of ASTM F477. Gaskets shall be installed by the pipe manufacturer and covered with a removable, protective wrap to ensure the gasket is free from debris. A joint lubricant available from the manufacturer shall be used on the gasket and bell during assembly.
 3. Pipe entrances at catch basins shall be made with a mortar made with Type II cement. Mortar mixture shall follow instructions provided by cement manufacturer. Pipe connections at drain manholes and water quality structures shall be made with integral flexible rubber sleeves and Corrugated Pipe Adapters designed for use with the pipe and sleeves.

2.14 REINFORCED CONCRETE PIPE (CLASS IV; 12 THROUGH 48 INCHES)

- A. General: Provide pipes of the following materials of class indicated. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.
1. The pipe shall have an interior surface, which is smooth and even, free from roughness, projections, indentations, offsets, or irregularities of any kind. Pipe shall conform to ASTM "Specifications for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe," Designation: C76 and shall be Wall B for the Class IV and V, as noted on the drawings, and with additions and exceptions as follows:
 2. Type II cement shall be used unless otherwise approved by the Engineer. Admixtures shall not be used except with prior approval of the Engineer.
 3. Elliptical reinforcement will not be permitted. Longitudinal reinforcement shall be continuous. Reinforcement shall have a minimum cover of $\frac{3}{4}$ inch. Pipe shall have no lifting holes.

4. Absorption shall be as specified under "Tests of Materials and Pipe Units."
 5. Pipes manufactured by the centrifugal process or in vertical forms shall be cast of wet mix concrete. Concrete cast in vertical forms shall be consolidated by internal or external mechanical vibration or both. The vibrating equipment shall be operated at high speed (more than 5,000 rpm) and have a low amplitude. Pipes manufactured by the modified packer process shall have a supplementary concrete densification operation that shall assure the attainment of full bond between reinforcement and concrete and also eliminate any displacement of the reinforcement. Additional passes with the revolving packerhead or the use of additional vibrators attached to the platform or exterior forms will not be acceptable.
 6. Pipe units shall have a minimum laying length of 8-feet except as otherwise indicated or allowed by the Engineer.
 7. Pipe may be rejected for any of the following reasons:
 - a. Exposure of any wires, positioning spacers or chairs used to hold the reinforcement cage in position, or steel reinforcement in any surface of the pipe, except as permitted by Section 8.2 of ASTM C76.
 - b. Transverse reinforcing steel found to be in excess of 1/4-inch out of specified position after the pipe is molded.
 - c. Any shattering or flaking of concrete as a crack.
 - d. Voids, with the exception of a few minor bugholes, on the interior and exterior surfaces of the pipe exceeding 1/4-inch in depth, unless properly and soundly pointed with mortar or other approved material.
 - e. A hollow spot (identified by tapping the internal surface of the pipe) which is greater than 30-inches in length or wider than 3 times the specified wall thickness.
 - f. Defects that indicate imperfect molding of concrete; or any surface defect indicating honeycomb or open texture (rock pockets) greater in size than area equal to a square with a side dimension of 2½ times the wall thickness or deeper than two times the maximum graded aggregate size; or local deficiency of cement resulting in loosely bonded concrete.
 - g. Any of the following:
 - 1) A crack having a width of 0.005 to 0.01-inches throughout a continuous length of 36-inches or more.
 - 2) A crack having a width of 0.0 to 0.03-inches or more throughout a continuous length of 1-foot or more.
 - 3) Any crack greater than 0.005-inches extending through the wall of the pipe and having a length in excess of the wall thickness.
 - 4) Any crack showing two visible lines of separation for a continuous length 2-feet or more, or an interrupted length of 3-feet or more anywhere in evidence, both inside and outside.
 - 5) Cracks anywhere greater than 0.03-inches in width.
 - h. Application of any wash coat of cement or grout to the pipe will not be permitted without approval of the Engineer. Any pipe dressing procedures shall be subject to the approval of the Engineer.
- B. Joints on Reinforced Concrete Pipe:
1. Pipe joints for all reinforced concrete pipe shall be of the rubber gasket type in which the gaskets are in compression and which will permit both longitudinal and angular movement. Each unit of pipe shall be provided with proper ends made of concrete formed true to size and formed on machined rings to ensure accurate joint surfaces.

2. Joints and gaskets for pipe shall be the O-ring gasket type and shall conform to the requirements of ASTM C443 and the additional requirements specified.
 3. Joints shall be of such design that when tested under an average internal hydrostatic pressure of 13 pounds per square inch for a period of 10 minutes, no visible leakage will result. The diameters of the joint surfaces which compress the gasket shall not vary from the true diameters by more than 1/16-in or the amount permitted by the appropriate above-mentioned ASTM Standard Specifications, whichever is less.
 4. Gaskets shall be of a composition and texture which is resistant to common ingredients of stormwater and groundwater, and which will endure permanently under the conditions likely to be imposed by this service. Gaskets shall be the product of a manufacturer regularly engaged in the manufacture of rubber gaskets for pipe joints.
- C. Flared End Sections: Reinforced Concrete Pipe flared end sections shall conform to requirements of AASHTO M170, minimum Class IV.

2.15 SUBSURFACE INFILTRATION CHAMBERS

- A. Subsurface detention chambers shall be HDPE chamber system as manufactured by StormTech, Cultec, or similar. The chambers will be handled, stored, and installed according to manufacturer's specifications and details. The chambers will be placed on a drainage course bed with a minimum of depth of six inches. The chambers shall not be placed with backfill depths greater than 96" to surface as per manufacturer's details.
- B. The nominal storage volume of stormwater chambers shall be 74.9 cubic feet per chamber, including the volume of drainage course bedding.
- C. The galley shall have both of its ends open to allow for unimpeded hydraulic flows and for visual inspection and maintenance of the row's entire length. The galley shall have a circular, indented, flat surface on the top for an inspection port or clean-out.
- D. The galley shall be analyzed and designed using AASHTO methods for thermoplastic culverts contained in the LRFD Bridge Design Specifications, 2nd Edition, including Interim Specifications through 2001. Design live load shall be the AASHTO HS20 vehicle. Design shall consider earth and live loads as appropriate for the specified depth of fill.
- E. The end cap shall be designed to fit into any corrugation of a galley, which allows capping a galley that has its length trimmed and segmenting rows into storage basins of various lengths.
- F. The end cap shall have saw guides to allow easy cutting for various diameters of pipe that may be used to inlet the system. The end cap shall have excess structural adequacies to allow cutting an orifice of the required size at any invert elevation.
- G. The primary face of an end cap shall be curved outward to resist horizontal loads generated near the edges of beds.

2.16 FILTER FABRIC

- A. Filter Fabric used as a drainage medium shall be a needle-punched, non-woven geotextile made from polypropylene or polyethylene filaments or yarns.
- B. Filter fabric shall be inert to organic chemicals commonly encountered in the soil.
- C. Filter fabric shall be meet AASHTO M288 Survivability Class 2 Standards.
- D. The edges of filter fabric shall overlap a minimum of one foot.

- E. Filter fabric shall be in compliance with the following properties, measured as per the referenced test methods:

PROPERTY	Required Value	TEST METHOD
Grab Tensile Strength	160 lbs. (min.)	ASTM D 4632
Elongation @ Failure	50% (min.)	ASTM D 4632
Trapezoidal Tear Strength	60 lbs. (min.)	ASTM D 4533
CBR Puncture Strength	410 lbs. (min.)	ASTM D 6241
Permittivity	1.5 sec ⁻¹ (min.)	ASTM D 4491
Water Flow Rate	110 gal./min./SF (min.)	ASTM D 4491
Apparent Opening Size	#70 Standard US Sieve	ASTM D 4751
U.V. Radiation Stability	70% (min.)	ASTM D 4355

2.17 CRUSHED STONE

- A. Crushed stone shall consist of durable crushed rock or durable crushed gravel stone, free from ice and snow, sand, clay, loam, or other deleterious or organic material. The crushed stone shall be uniformly blended and shall conform to the following requirements.

Percent Passing by Weight		
Sieve Size	3/4-inch Stone	1/2-inch Stone
1-inch	100	---
3/4-inch	90-100	---
5/8-inch	---	100
1/2-inch	10-50	85-100
3/8-inch	0-20	15-45
No. 4	0-5	0-15
No. 8	---	0-5

2.18 DRAIN COUPLINGS

- A. Drain Couplings shall be pressure rated at least equal to that of the pipe. The coupling sleeve, shall be 1/4-inch minimum thickness elastomeric polyvinylchloride with a minimum tensile strength of 1500 psi. The sleeve shall fit snugly onto the pipe to be joined and be resistant to common chemicals present in storm water. Adjustable pipe clamps shall consist of a slotted band that mate with the worm gear screw and a screw housing all manufactured of stainless steel, and suitable for underground service.

2.19 CLEANOUTS

- A. General: Provide cast-iron ferrule and countersunk brass cleanout plug, with round cast-iron access frame and heavy-duty, secured, scoriated cast-iron cover.
- B. The drain cleanouts shall be minimum 6-inch diameter or sized to match the service pipe, whichever is greater. The cleanout shall be complete with a flush mount over. The cleanout cover shall be clearly marked "DRAIN" and shall be minimum eight inches in diameter or two inches greater than the cleanout size, whichever is greater. Cleanouts shall include a watertight cap.

- A. Detectable Underground Warning Tapes: Acid and alkali-resistant polyethylene plastic film warning tape, 6-inches wide by 4-mils. minimum thickness, with continuously printed caption in black letters "CAUTION - xxxxx LINE BURIED BELOW." The text and color of the tape shall be as shown in the table below. The tape shall have a metallic core encased in a protective jacket for corrosion protection and be detectable by a metal detector when the tape is buried up to 2.5-feet deep.

Color	Utility
Safety Red	Electric
High Visibility Safety Yellow	Gas, Oil, Steam
Safety Alert Orange	Telephone, Communications, Cable Television
Safety Precaution Blue	Water System, Irrigation
Safety Green	Sanitary Sewer, Storm Sewer

PART 3 – EXECUTION

3.1 GENERAL INSTALLATION

- A. General: General Locations and Arrangements: Contract Drawings indicate the general location and arrangement of the underground storm drainage system piping. Location and arrangement of piping layout take into account many design considerations. Install the piping as indicated, to the extent practical. Any modifications to the layout of the storm drainage system shall be submitted to the Engineer for review and approval at least five days prior to the start of the affected work.
- B. Install piping beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings in accordance with manufacturer's recommendations, accepted practices, and utility owner's requirements. Maintain swab or drag in line and pull past each joint as it is completed.
- C. All pipe shall be laid in the dry. Adequate measures shall be taken to prevent floatation of pipe in the trench.
- D. Whenever encountered within the trench, existing abandoned water, sewer, and/or drain lines shall be removed within the trench limits, unless otherwise noted. The remaining portion of the abandoned lines shall be plugged at all open ends.
- E. When bell and spigot pipes are used, bell holes shall be dug in the bedding to accommodate the bells. They shall be deep enough to ensure that the bell does not bear on the bottom of the hole but shall be excessively wide in the longitudinal direction of the installation.
- F. Use manholes for changes in direction, except where a fitting is indicated. Use fittings for branch connections, except where direct tap into an existing storm drain is indicated.
- G. Use proper size increasers, reducers, and couplings, where different size or material of pipes and fittings are connected. Reduction of the size of piping in the direction of flow is prohibited without the written approval of the Engineer.
- H. Install piping pitched down in direction of flow as indicated on the Contract Drawings.

- I. Extend storm drainage system piping to connect to building drain services, of sizes and in locations indicated on the Contract Drawings.
- J. Install piping in accordance with governing authorities having jurisdiction, except where more stringent requirements are indicated.
- K. Acceptance of Pipe: Acceptance will be on the basis of tests specified herein before. The quality of all materials used in the pipe, the process of manufacture, and the finished pipe shall be subject to review by the Engineer. Inspection may be made at the place of manufacture, or on the work site after delivery or at both places and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though sample pipe units may have been accepted as satisfactory at the place of manufacture. All pipe which is rejected shall be immediately removed from the project site by the Contractor.
- L. Pipe Storage: Pipe sections shall not be stored on areas over the newly laid pipe or other pipelines which might be damaged by the superimposed load, and storage sections shall be restricted to approved areas.
- M. Handling Pipe: Each pipe unit shall be handled into its position in the trench only in such manner and by such means, as the Engineer accepts as satisfactory. The Contractor will be required to furnish suitable devices to permit satisfactory support of all parts of the pipe unit when it is lifted.
- N. Laying Pipe: Except where a concrete cradle or envelope is required, the pipe shall be laid in a crushed stone cradle. In trenches, no blocking or supporting of the piping by concrete, stones, bricks, wooden wedges, or method other than bedding the pipe on crushed stone will be permitted. Each length of pipe shall be shoved home against the pipe previously laid and held securely in position. Joints shall not be "pulled" or "cramped" without approval of the Engineer.
- O. Jointing Pipe: After the pipe are aligned in the trench and are ready to be jointed, all joint surfaces shall be cleaned.
- P. Alignment and Placement: All pipe shall be laid with extreme care as to grade and alignment. Each pipe shall be so laid as to form a close joint with the next adjoining pipe and bring the inverts continuously to the required grade.
 - 1. Stakeout of drain work and setting of line and grade is the responsibility of the Contractor.
 - 2. The Contractor shall establish centerline and offset stakes at each manhole, plus one intermediate centerline and offset stake as a check point between manholes. Laser aligning shall not be used to establish a continuous line in excess of 400-feet.
- Q. Cleaning: Care shall be taken to prevent earth, water, and other materials from entering the pipeline. As soon as possible after the pipe and manholes are completed, the Contractor shall clean out the pipeline and manholes being careful to prevent soil, water and debris from entering any existing drainage system.
 - 1. Place plugs in end of uncompleted conduit at end of day or whenever work stops.
 - 2. Flush lines between manholes to remove collected debris.
- R. Review of Completed Storm Drain System: The completed drain system shall be visually inspected by the Owner's Representative. If the visual observation of the completed drain or any part thereof shows any pipe, manhole, or joint to be of defective work or material, the defect shall be replaced or repaired as directed by the Engineer or the Owner's Representative. The Contractor shall coordinate and provide site access for inspection.

3.2 PLACEMENT OF DUCTILE IRON PIPE AND FITTINGS

- A. Care shall be taken in loading, transportation, and unloading to prevent injury to the pipe or coatings. Pipe or fittings shall not be dropped. All pipe and fittings shall be examined before placement, and no piece shall be installed which is found to be defective. Any damage to the pipe coatings shall be repaired as directed by the Engineer.
- B. If any defective pipe is discovered after it has been placed, it shall be removed and replaced with a sound pipe in a satisfactory manner by the Contractor, at his own expense. All pipe and fittings shall be kept clean until they are used in the work, be thoroughly cleaned before placement, and when placed, shall conform to the lines and grades required. Ductile iron pipe and fittings shall be installed in accordance with requirements of AWWA Standard Specification C600 except as otherwise provided herein. A firm even bearing throughout the length of the pipe shall be constructed by compacting gravel borrow around the pipe and up to the springline.
 - 1. Blocking will not be permitted.
- C. All pipes shall be sound and clean before placement. When pipe laying is not in progress, including lunchtime, the open ends of the pipe shall be temporarily closed by watertight plug or other acceptable means. Alignment shall be maintained during placement. The deflection at joints shall not exceed sixty percent of that recommended by the manufacturer. Fittings, in addition to those shown on the plans, shall be provided, if required, in crossing utilities, which may be encountered upon opening the trench. Solid sleeves shall be used only where allowed by the Engineer.
- D. When cutting pipe is required, the cutting shall be done by machine, leaving a smooth cut at right angles to the axis of the pipe. Cut ends of pipe to be used with a push-on type bell shall be beveled to conform to the manufactured spigot end.
- E. The Contractor shall take care not to damage pipe by impact, bending, compression, or abrasion during handling, and installation. Joint ends of pipe especially shall be kept clean.
- F. Pipe shall be stored above ground at a height no greater than 5 feet and with even support for the pipe barrel.
- G. Only nylon protected slings shall be used for handling the pipe. No hooks, chains or bare cables will be permitted.
- H. Gaskets shall be shipped in cartons and stored in a clean area, away from grease, oil, heat, direct sunlight and ozone producing electric motors.
- I. Jointing of ductile iron push on pipe and fittings shall be done in accordance with the printed recommendations of the manufacturer and as specified. The last 8 inches of the outside of the spigot end of pipe and the inside of the bell end of pipe shall be thoroughly cleaned. The joint surfaces and the gasket shall be painted with a lubricant just prior to making up the joint. The spigot end shall then be gently pushed home into the bell. The position of the gasket shall be checked to ensure that the joint has been properly made and is watertight. Care shall be taken not to exceed the manufacturer's recommended maximum deflection allowed for each joint.
 - 1. Jointing Ductile Iron Pipe (Push-On Type): Push-on joints shall be made in strict accordance with the manufacturer's instructions. Pipe shall be laid with bell ends looking ahead. A rubber gasket shall be inserted in the groove of the bell end of the pipe, and the joint surfaces cleaned and lubricated. The plain end of the pipe to be entered shall then be inserted in alignment with the bell of the pipe to which it is to be

joined, and pushed home with a jack or by other means. After joining the pipe, a metal feeler shall be used to make certain that the rubber gasket is correctly located.

2. Jointing Mechanical Joint Fittings: Mechanical joints at fittings and where designated shall be installed in accordance with the "Notes on Method of Installation" under ANSI Specification A 21.11 and the instructions of the manufacturer. To assemble the joints in the field, the Contractor shall thoroughly clean the joint surfaces and rubber gasket with soapy water before tightening the bolts. Bolts shall be tight to the specified torque. Under no condition shall extension wrenches or pipes over handles or ordinary ratchet wrenches be used to secure greater leverage.

J. Installation and jointing of ductile iron pipe shall be in accordance with AWWA C600, Sections 9b and 9c, latest revision, as applicable.

K. Ductile iron pipe installed within 5-feet of gas lines shall be fully encased with polyethylene material. Polyethylene shall be 8 millimeters thick and comply with AWWA C 105.

3.3 PVC PIPE

A. General: Install piping in accordance with governing authorities having jurisdiction, except where more stringent requirements are indicated.

B. PIPE HANDLING

1. All pipe and fittings shall be carefully handled from the truck onto the ground and into the trench or excavation so as to prevent damage to the pipe. Pipes shall be kept free of dirt and foreign material, especially on the inside. Joint ends of pipe shall especially be kept clean.
2. Pipe stored on site shall be protected from heat and direct sun light and shall be suitably ventilated.
3. Pipe or fittings shall not be dropped. All pipe or fittings shall be examined before laying, and no piece shall be installed which is found to be defective.

C. ALIGNMENT AND PLACEMENT OF PVC PIPE

1. Bedding material for the pipe must be installed with care in the area around the pipe. Bedding material must be placed to provide uniform and adequate support under pipe. Do not use blocking to bring pipe up to grade.
2. Provide bell holes at each joint to permit joint to be assembled properly while maintaining uniform pipe support.
3. Place and consolidate the bedding material under the pipe haunch to provide adequate side support while avoiding both vertical and lateral displacement of pipe.
4. Initial backfill must be completed to a point at least 12-inches over the top of the pipe and be hand placed. Use little or no tamping of initial backfill directly over the top of pipe. Compaction methods may be utilized during final backfilling.
5. No length of pipe shall be laid until the proceeding lengths of pipe have been thoroughly embedded in place, to prevent movement or disturbance of the pipe alignment.
6. Full lengths of pipe shall be used in the installation except that partial lengths may be used at the entrance to structures, and to accommodate the required locations of service connection fittings.
7. Pipe entrances to structures shall be cut flush with the inside face of the structure and cut ends of the pipe surface within the structure shall be properly rounded and finished so that there will be no protrusion, ragged edges or imperfections that will impede or affect the hydraulic characteristics of the stormwater flow. The method of cutting and finishing shall be subject to the approval of the Engineer.

8. The Contractor shall protect the installation at all times during construction. The movement of construction equipment, vehicles and loads over and adjacent to any pipe shall be performed at the Contractor's own risk.
9. Drain pipes shall be laid to the required grades by use of a laser and target system, unless otherwise specifically approved by the Engineer.
10. Jointing of PVC drain pipe and fittings shall be done in accordance with the printed recommendations of the manufacturer and as specified. The bell end of the pipe shall be thoroughly cleaned. The joint surfaces and the gasket shall be lubricated prior to making up the joint. The position of the gasket shall be checked to ensure the joint has been properly made and is watertight. Care shall be taken not to exceed the manufacturer's recommended maximum deflection allowed for each joint.
11. PVC pipe shall be pushed home by hand or with the use of bar and block. The use of power equipment, such as a backhoe bucket, is not acceptable.
12. Field-cut pipe ends shall be cut square and the pipe surface beveled to the size and shape of a factory-finished beveled end. All sharp edges shall be rounded off.

3.4 INSTALLATION OF REINFORCED CONCRETE PIPE AND PIPE FITTINGS

- A. General: Install piping in accordance with ASTM D2321, the governing authorities having jurisdiction of the utility, and the manufacturer's instructions, except where more stringent requirements are required by the Contract Documents.
- B. Acceptance of Pipe: Acceptance will be on the basis of tests specified hereinbefore. The quality of all materials used in the pipe, the process of manufacture, and the finished pipe shall be subject to review by the Engineer. Inspection may be made at the place of manufacture, or on the work site after delivery or at both places and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though sample pipe units may have been accepted as satisfactory at the place of manufacture. All pipe which is rejected shall be immediately removed from the project site by the Contractor at no cost to the Owner.
- C. Pipe Storage: Pipe sections shall not be stored on areas over the newly laid pipe or other pipelines which might be damaged by the superimposed load, and storage sections shall be restricted to approved areas.
- D. Laying Pipe: Except where a concrete cradle or envelope is required, the pipe shall be laid in a crushed stone cradle. In trenches, no blocking or supporting of the piping by concrete, stones, bricks, wooden wedges, or method other than bedding the pipe on crushed stone will be permitted. Each length of pipe shall be shoved home against the pipe previously laid and held securely in position. Joints shall not be "pulled" or "cramped" without approval of the Engineer.
- E. Jointing Pipe: After the pipes are aligned in the trench and are ready to be jointed, all joint surfaces shall be cleaned.
- F. Alignment and Placement: All pipes shall be laid with extreme care as to grade and alignment. Each pipe shall be so laid as to form a close joint with the next adjoining pipe and bring the inverts continuously to the required grade.
 1. Stakeout of drain work and setting of line and grade is the responsibility of the Contractor.
 2. The Contractor shall establish centerline and offset stakes at each manhole, plus intermediate centerline and offset stakes as needed to ensure proper alignment and grade. Laser aligning shall not be used to establish a continuous line in excess of 400-feet.

- G. Cleaning: Care shall be taken to prevent earth, water, and other materials from entering the pipeline. As soon as possible after the pipe and manholes are completed, the Contractor shall clean out the pipeline and manholes being careful to prevent soil, water, and debris from entering any existing Drain.
 - 1. Place plugs in end of uncompleted conduit at end of day, or whenever work stops.
 - 2. Flush lines between manholes to remove collected debris.
- H. Review of Completed Reinforced Concrete Pipe System: If the visual observation of the completed drain or any part thereof shows any pipe, manhole, or joint to be of defective work or material the defect shall be replaced or repaired as directed at no cost to the Owner. The visual observation shall be conducted by the Engineer and any defects shall be as identified by such. The Contractor shall coordinate and provide site access for the Owner.

3.5 INSTALLATION OF CORRUGATED POLYETHYLENE PIPE AND PIPE FITTINGS

- A. General: Install Corrugated Polyethylene Pipe in accordance with ASTM D2321 and governing authorities having jurisdiction, except where more stringent requirements are indicated.
- B. Acceptance of Pipe: Acceptance will be on the basis of tests specified herein before. The quality of all materials used in the pipe, the process of manufacture, and the finished pipe shall be subject to review by the Engineer. Inspection may be made at the place of manufacture, or on the work site after delivery or at both places and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though sample pipe units may have been accepted as satisfactory at the place of manufacture. All pipe which is rejected shall be immediately removed from the project site by the Contractor.
- C. Pipe Storage: Pipe sections shall not be stored on areas over the newly placed pipe or other pipelines which might be damaged by the superimposed load, and storage sections shall be restricted to approved areas.
- D. Handling Pipe: Each pipe unit shall be handled into its position in the trench only in such manner and by such means, as the Engineer accepts as satisfactory. The Contractor will be required to furnish suitable devices to permit satisfactory support of all parts of the pipe unit when it is lifted.
- E. Alignment and Placement: All pipe shall be placed with extreme care as to grade and alignment. Each pipe shall be so placed as to form a close joint with the next adjoining pipe and bring the inverts continuously to the required grade.
 - 1. Stakeout of drain work and setting of line and grade is the responsibility of the Contractor.
 - 2. The Contractor shall establish centerline and offset stakes at each manhole, plus intermediate centerline and offset stake as needed to ensure proper alignment and grade between manholes. Laser aligning shall not be used to establish a continuous line in excess of 400-feet.
 - 3. Bedding material for the pipe must be installed with care in the area around the pipe. Bedding material must be placed to provide uniform and adequate support under pipe. Do not use blocking to bring pipe up to grade. Bedding shall be crushed stone.
 - 4. Provide bell holes at each joint to permit joint to be assembled properly while maintaining uniform pipe support.
 - 5. Place and consolidate the bedding material under the pipe haunch to provide adequate side support while avoiding both vertical and lateral displacement of pipe.

6. Initial backfill must be completed to a point at least 12-inches over the top of the pipe and be hand placed. Use little or no tamping of initial backfill directly over the top of pipe. Compaction methods may be utilized during final backfilling.
7. No length of pipe shall be laid until the proceeding lengths of pipe have been thoroughly embedded in place, to prevent movement or disturbance of the pipe alignment.
8. Full lengths of pipe shall be used in the installation except that partial lengths may be used at the entrance to structures, and to accommodate the required locations of service connection fittings.
9. Pipe entrances to structures shall be cut flush with the inside face of the structure, and cut ends of the pipe surface within the structure shall be properly finished so that there will be no protrusion, ragged edges or imperfections that will impede or affect the hydraulic characteristics of the stormwater flow. The method of cutting and finishing shall be subject to the approval of the Engineer.
10. The Contractor shall protect the installation at all times during construction. The movement of construction equipment, vehicles and loads over and adjacent to any pipe shall be performed at the Contractor's own risk.
11. Jointing of pipe and fittings shall be done in accordance with the printed recommendations of the manufacturer and as specified. The bell end of the pipe shall be thoroughly cleaned. The joint surfaces and the gasket shall be lubricated prior to making up the joint. The position of the gasket shall be checked to ensure the joint has been properly made and is watertight. Care shall be taken not to exceed the manufacturer's recommended maximum deflection allowed for each joint.
12. Each length of pipe shall be pushed home by hand or with the use of bar and block. The use of power equipment, such as a backhoe bucket, is not acceptable.
13. Field-cut pipe ends shall be cut square.

3.6 INSTALLATION OF DRAIN MANHOLES AND CATCH BASINS

- A. The bases shall be supported on a compacted level foundation of gravel borrow a minimum of 12 inches thick. Crushed stone may be substituted for gravel borrow if field conditions at the bottom of the excavation are wet.
 1. The Contractor shall install the manholes and catch basins as soon as the pipe laying reaches the location of the structures.
 2. The Contractor shall accurately locate each manhole and catch basin and set accurate templates to conform to the required line and grade. Any manhole or catch basin which is not installed in the correct location or oriented improperly shall be removed and rebuilt in its proper location, alignment, and orientation at no additional cost to the Owner.
 3. Manhole risers and tops shall be installed using approved butyl rubber sealant or rubber gasket for sealing joints of manhole risers and tops; jointing shall be performed in accordance with the manufacturer's recommendations. Manhole risers and tops shall be installed level and plumb. Water shall not be permitted to rise over newly made joints, nor until after inspection as to their acceptability. All jointing shall be done in a manner to ensure watertight joints.
 4. Openings shall be provided in the precast concrete manhole sections to receive entering pipes and these openings shall be made at the place of manufacture. Pipe entrances at catch basins shall have plain beveled openings to accept the type of pipe specified and to be sealed with non-shrink grout. Grout mixture shall follow instructions provided by manufacturer. Pipe connections at drain manholes shall be made as indicated on the Drawings with either non-shrink grout or integral flexible rubber sleeves and Corrugated Pipe Adapters designed for use with the pipe and sleeves. For grouted joints, surface between pipe and wall shall be completely filled with non-shrink grout

and troweled to provide a smooth surface conforming to both the outside and inside structure wall.

5. Care shall be taken to ensure that the openings are made to permit setting of the entering pipe at its correct elevation as indicated or directed. Manhole risers and tops shall be installed so that the manhole steps shall be in alignment.
6. All holes used for handling shall be thoroughly plugged with non-shrink grout.
7. Cutting or tampering in the field, for purpose of creating new sidewall openings or altering existing openings, will not be permitted except at the discretion of the Engineer or if necessary concrete block manhole(s) shall be used.
8. All interior manhole joints where the sealing material is not flush with the inside wall shall be grouted with non-shrink mortar and finished by hand/wet-brush.
9. A cast-in-place concrete invert shelf and channel shall be poured and shaped to the lower half of the pipes
10. Clean all debris, mortar, and soil from the bottom of all structures prior to final acceptance of the project.

3.7 SETTING MANHOLE FRAMES AND COVERS AND CATCH BASIN FRAMES AND GRATES

- A. Manhole and catch basin frames shall be set with tops conforming accurately to the grade of the pavement or finished ground surface or as indicated on the Contract Drawings or as directed.
- B. Brick shall be used to bring the frames to the required elevation.
 1. Frames shall be set centered with the opening in the top of the precast structure on two to four courses of brick in a full bed of mortar. A thick ring of mortar extending to the outer edge of brick or concrete shall be placed all around the bottom flange of the cast iron frame. The mortar shall be smoothly finished to a height of 5 inches above the flange for 8-inch frames and sloped to shed water away from the frame.
 2. Completed brick installation shall be coated with mortar at least a $\frac{3}{4}$ inch thick on the outside to provide a fully sealed and watertight collar between the top manhole section and the cover frame.
 3. Only clean bricks shall be used in brick work to adjust frame elevations. The brick shall be moistened by suitable means.
- C. Manhole covers shall be left in place in the frame until completion of other work at the manholes.
- D. Where directed, the castings shall be temporarily set at such grades as to provide drainage during construction. The castings of structures located within the pavement area shall not be completely set to the established grade until the bottom course of pavement has been laid. The final setting of all other casting shall be performed at the proper stage of construction.

3.8 CHANGE IN TYPE

- A. When an existing catch basin is to be converted to a manhole, the frame and grate shall be carefully removed and a new frame and cover installed to finish grade. If in the opinion of the Engineer the existing casting is reusable, it may be reused in the work, otherwise, it shall be disposed of off-site.
 1. The sump of the catch basin shall be thoroughly cleaned of debris and silt and the interior surfaces brushed to remove contaminants.

2. The sump shall be thoroughly filled with compacted gravel to a level no greater than 6 inches below the pipe invert. A cast-in-place concrete invert shelf and channel shall be poured and shaped to the lower half of the pipes.
3. New openings in existing structures shall be carefully cut with power saws of the proper size and elevation to accept the new connection. Damage to the structure caused by the Contractor's construction methods shall be repaired at no additional cost.

3.9 INSTALLATION OF WATER QUALITY STRUCTURES

- A. Contractor shall take appropriate action to protect all structure components throughout the installation and construction process. Care shall be taken in loading, transporting, and unloading to prevent damage to materials during storage and handling.
- B. Install water quality structures per manufacturer's specifications.
- C. The installation of a precast concrete structure should conform to ASTM C 891 for the construction of manholes.
- D. The precast concrete structure shall be installed in sections in the following sequence:
 1. Aggregate Base: Structure shall be supported on a compacted level foundation of gravel borrow or crushed stone a minimum of 12 inches thick.
 2. Base Slab
 3. Treatment chamber section(s)
 4. Transition slab (if required)
 5. Bypass Section
 6. Connect inlet and outlet pipes
 7. Riser section and/or transition slab (if required)
 8. Maintenance rider section(s) (if required)
 9. Frame and access cover
- E. The precast base shall be placed level at the specified grade. The entire base should be in contact with the underlying compacted granular material. Subsequent sections, complete with joint seals, shall be installed in accordance with the precast concrete manufacturer's installation requirements.
- F. Adjustment of the stormwater quality treatment structure can be performed by lifting the upper sections free of the excavated area, re-leveling the base, and re-installing the sections. Damaged sections and gaskets shall be repaired or replaced as necessary. Once the stormwater quality treatment structure has been constructed, any lift holes shall be plugged watertight with mortar or non-shrink grout.
- G. Internal components requiring field installation shall be installed by the Contractor in accordance with the manufacturer's specifications and installation requirements.
- H. Inlet and outlet pipes should be securely set into the structure using approved pipe seals (flexible boot connections) so that the structure is watertight.
- I. Grade rings shall be installed to set the frame and cover at the required elevation. The grade rings shall be laid in a full bed of mortar with successive units being joined using sealant recommended by the manufacturer. Frames for the cover shall be set in a full bed of mortar at the elevation specified.

- J. If precast tank sections are to be field assembled, adequate waterproofing shall be used at the joint to resist the waterhead at that joint.

3.10 INSTALLATION OF PRECAST CONCRETE TANKS AND VAULTS

- A. The bases shall be supported on a compacted level foundation of gravel borrow a minimum of 12 inches thick. Crushed stone may be substituted for gravel borrow if field conditions at the bottom of the excavation are wet.
- B. The precast base shall be placed level at the specified grade. The entire base should be in contact with the underlying compacted granular material. Subsequent sections, complete with joint seals, shall be installed in accordance with the precast concrete manufacturer's recommendations. Structure sections shall be installed level and plumb. Water shall not be permitted to rise over newly made joints, nor until after inspection as to their acceptability. All jointing shall be done in a manner to ensure watertight joints.
- C. Adjustment of the structure can be performed by lifting the upper sections free of the excavated area, re-leveling the base, and re-installing the sections. Damaged sections and gaskets shall be repaired or replaced as necessary. Once the structure has been constructed, any lift holes shall be plugged watertight with mortar or non-shrink grout. Any precast structure which is not installed in the correct location or oriented improperly shall be removed and rebuilt in its proper location, alignment, and orientation at no additional cost to the Owner.
- D. Inlet and outlet pipes should be securely set into the structure using approved pipe seals (flexible boot connections, where applicable) so that the structure is watertight. Care shall be taken to ensure that the openings are made to permit setting of the entering pipe at its correct elevation as indicated or directed. Cutting or tampering in the field, for purpose of creating new sidewall openings or altering existing openings, will not be permitted.
- E. Grade rings shall be installed to set the frame and cover at the required elevation. The grade rings shall be laid in a full bed of mortar with successive units being joined using sealant recommended by the manufacturer. Frames for the cover shall be set in a full bed of mortar at the elevation specified.
- F. Clean all debris, mortar, and soil from the bottom of all structures prior to final acceptance of the project.

3.11 AREA DRAINS

- A. Install area drains per manufacturer specifications.
- B. The specified PVC surface drainage inlet shall be installed using conventional flexible pipe backfill materials and procedures. The backfill material shall be crushed stone or other granular material meeting the requirements of class 2 material as defined in ASTM D2321. Bedding and backfill for surface drainage inlets shall be placed and compacted uniformly in accordance with ASTM D2321. The drain basin body will be cut at the time of the final grade. No brick, stone or concrete block will be required to set the grate to the final grade height.
- C. For H-20 load rated installations, a concrete ring shall be poured under and around the grate and frame as indicated on the Drawings.

3.12 INLINE DRAINS

- A. The specified PVC surface drainage inlet shall be installed using conventional flexible pipe backfill materials and procedures. The backfill material shall be crushed stone or other granular material meeting the requirements of class 1 or class 2 material as defined in ASTM

D2321. Bedding and backfill for surface drainage inlets shall be well placed and compacted uniformly in accordance with ASTM D2321. The drain basin body will be cut at the time of the final grade. No brick stone or concrete block will be required to set the grate to the final grade height. For H-20 load rated installations, a concrete ring will be poured under and around the grate and frame. The concrete slab must be designed taking into consideration local soil conditions, traffic loading, and other applicable design factors. For other installation considerations such as migration of fines, ground water, and soft foundations refer to ASTM D2321 guidelines.

3.13 TRENCH DRAINS

- A. Install trench drain structures per manufacturer specifications.

3.14 DRAIN COUPLINGS

- A. Couplings which are factory manufactured shall be installed at all connections from existing pipe to proposed pipe unless the existing pipe is the same material as the proposed pipe and the bell and spigot end of the pipes to be connected are compatible and free from defects. All drain couplings shall be installed in accordance with the manufacturer's recommendations for the types of pipe to be connected.

3.15 SUBSURFACE INFILTRATION CHAMBERS

- A. Install chambers, bedding, and inspection ports per manufacturer specifications.

3.16 CLEANOUTS

- A. Install cleanouts and extensions from drain pipe to cleanout at grade as indicated on the Contract Drawings. Set cleanout frame and cover in concrete 18 by 18 by 6-inches deep, except where location is in bituminous or concrete paving. Set top of cleanout 1-inch above surrounding earth grade or flush with grade when installed in paving.

3.17 TAP CONNECTIONS

- A. Make connections to existing underground drainage structures, so that finished work will conform as nearly as practicable to requirements specified for new work. The contractor shall verify the location, size, invert, and type of existing pipes at all points of connection prior to make the connections.
- B. Make branch connections from side into existing piping by installing a wye or T-wyes, and couplings manufactured for use with the same type of pipe as indicated on the Contract Drawings. The Contractor shall install a 45-degree wye branch or 90-degree tee fittings in the drain pipe at all locations where storm service pipe connections are shown on the Drawings. Connections of the storm service pipes shall be made into the wye branches or tees by means of 45-degree bends. The connections shall be made thoroughly watertight and concrete shall be placed under each connection to bear on undisturbed earth and firmly support the connection.
- C. Protect existing piping and structures to prevent concrete or debris from entering while making tap connections. Remove debris, concrete, or other extraneous material that may accumulate.
- D. Connections into existing drainage facilities shall be performed in accordance with the requirements of the Town of Wakefield. The Contractor shall comply with all such requirements, including securing of all required permits and paying the costs thereof.

- A. General: Conduct excavation and backfill operations for structure and pipe installations in accordance with Section 312000 – EARTH MOVING, local requirements, and the contract documents.
- B. Initial backfill shall be placed evenly on both sides of the pipe to distribute the load and not to cause movement or deflection of the pipe.

3.19 INSTALLATION OF IDENTIFICATION

- A. Install continuous plastic underground warning tape during back-filling of trench for underground storm drainage system piping. Locate tape two-feet below finished grade, directly over piping.

3.20 FIELD TESTING OF CORRUGATED POLYETHYLENE PIPING

- A. The pipe shall be cleaned and visually inspected for offsets and obstructions prior to testing.
- B. The total length of each pipe installed on the project shall be tested or inspected for deflection. Conveyance pipes connecting at both ends to concrete drainage structures (catch basins, manholes, outlet control structures, water quality structures, etc.) shall be mandrel tested. Deflection of pipes used for stormwater detention/retention/infiltration systems, and pipes connecting to wye connections, building connections, trench drains, and other connections that do not allow mandrel testing shall be verified by visual inspection by the Owner's Representative during installation.
- C. Mandrel tests shall be performed by the Contractor and observed by the Owner's Representative not sooner than 20 days after completion of installation and compaction of backfill. Testing for pipes greater than 24-inch in diameter shall be tested prior to the installation of drainage structure cone and frame.
- D. Installed pipe shall be tested to ensure that the maximum deflection of the pipe does not exceed 7.5 percent of its base inside diameter. The base inside diameter is defined as the specified nominal diameter minus the allowable inside diameter tolerance of 1.5% but not more than 1/2 inch.
- E. A mandrel shall be pulled through the pipe by hand to ensure that maximum allowable deflections have not been exceeded. The mandrel diameter shall be verified and approved by the Owner's Representative prior to use. Use of an unapproved mandrel will invalidate the test. If the mandrel fails to pass through the pipe, the pipe will be deemed to be over-deflected.
- F. The mandrel shall be a rigid device, with an odd number of legs (9 legs minimum) having an effective length not less than its nominal diameter. The mandrel shall be fabricated of steel with pulling rings at each end.
- G. The minimum diameters at any point along the full length are as follows:

Nominal Size	Minimum Mandrel Diameter
6"	5.3"
8"	7.0"
10"	8.8"
12"	10.6"
15"	13.2"
18"	15.8"

24"	21.1"
30"	26.4"
36"	31.7"
42"	37.0"
48"	42.2"
54"	47.5"
60"	52.8"

3.21 FIELD QUALITY CONTROL

- A. Testing: Perform testing of completed piping in accordance with local authorities having jurisdiction.
- B. Video Inspections: Seven days after the completion of the backfilling of each section of new pipe, as defined as a length of pipe between two manholes, the Contractor will provide a televised inspection of the pipe to be submitted to the Designer. The Owner's Representative shall be present during the recording. The recording shall be in DVD color format with audio and will show a clear picture of the inside of the new pipe. If the Designer determines that the DVD is unacceptable for review the contractor shall re-televisize the line until an acceptable DVD has been submitted. In the event that the pipe is not acceptable for any reason relating to the proper construction of the pipe according to these specifications, the Contractor will be responsible to re-excavate and repair the defects to the satisfaction of the Designer at no additional cost.
- C. Cleaning: Clear interior of piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed.
 1. In large, accessible piping, brushes and brooms may be used for cleaning.
 2. Place watertight plugs in ends of uncompleted pipe at end of day or whenever work stops. If water is in the trench when work is resumed, the plug shall not be removed until the trench has been dewatered and all danger of water entering the pipe eliminated.
 3. Flush piping between manholes to remove collected debris.
- D. Interior Inspection: If deemed necessary by the Owner's Representative, inspect piping to determine whether line displacement or other damage has occurred.
 1. Make inspections after pipe between manholes has been installed and approximately 2 feet of backfill is in place, and again at completion of project.
 2. If inspection indicates poor alignment, debris, displaced pipe, infiltration or other defects, the Contractor shall correct such defects and reinspect.
- E. Prior to acceptance of the storm drainage system, the Contractor shall submit the following to the Architect and to the local authority:
 1. System As-Built Plan stamped by a Professional Land Surveyor or Engineer Registered in the Commonwealth of Massachusetts.
 2. Video inspection DVDs and report: The report shall document the observations of the video inspections.
 3. Deflection test report: The report shall fully describe the test procedures and list the test results. The report shall be signed by the Contractor's superintendent.

- A. Final inspection and acceptance of the storm drainage system shall be made by the Owner's Representative and the utility owner having jurisdiction of the particular system.
- B. Prior to placing the systems in service, all components shall be inspected, with the Owner's Representative present, to ensure that no debris or other contaminants are present. If necessary, the Contractor shall clean the structures and flush piping.
- C. The Contractor is responsible for coordinating and scheduling the inspection of the work by local jurisdictional authorities. No additional payment will be made for inspections and permits required in the performance of the work.

END OF SECTION