

PROJECT MANUAL

CONSTRUCTION DOCUMENTS VOLUME 2 OF 3

19 December 2025

Worcester South Division Fire Station Project

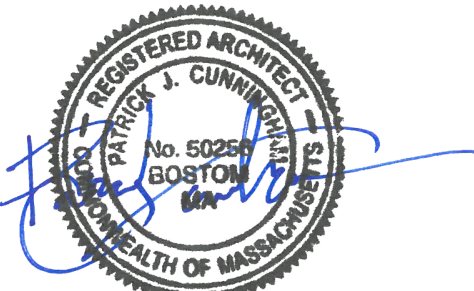
Worcester, MA

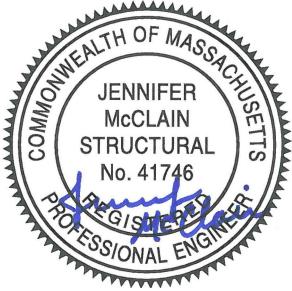
Perkins&Will Project Number: 157132.000

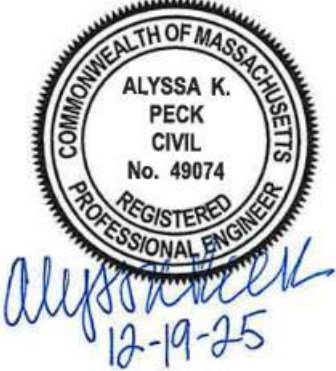
Perkins&Will

225 Franklin Street, Suite 700, Boston, MA 02110 | 617.478.0300

SECTION 00 01 07
PROFESSIONAL SEALS PAGE

ARCHITECT  12/19/25	NOT USED
NOT USED	NOT USED

STRUCTURAL ENGINEER 	NOT USED
NOT USED	NOT USED

CIVIL ENGINEER 	LANDSCAPE ARCHITECT 
NOT USED	NOT USED

MECHANICAL ENGINEER & PLUMBING ENGINEER 	ELECTRICAL ENGINEER & FIRE ALARM ENGINEER 
FIRE PROTECTION ENGINEER 	NOT USED

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FIRE PROTECTION

(Trade Bid Required)

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 the Specifications.
- B. Time, Manner and Requirements for Submitting Trade Bids:
 - 1. Trade bids for work under this Section shall be for the complete work and shall be filed in a sealed envelope with the Owner at a time and place as stipulated in the "INSTRUCTIONS TO BIDDERS".
 - a. The following should appear on the upper left hand corner of the envelope:
 - b. NAME OF TRADE BIDDER: (Insert name of trade bidder)
 - c. TRADE BID FOR SECTION: 21 00 01 – FIRE PROTECTION
 - d. Each trade bid submitted for work under this Section shall be on forms furnished by the Owner as required by Section 8 of Chapter 149A of the General Laws, as amended. Trade bid forms may be obtained at the office of the Owner.
 - 2. Trade bids filed with the Owner shall be accompanied by BID BOND or CASH or CERTIFIED CHECK or TREASURER'S CHECK or CASHIER'S CHECK issued by a responsible bank or trust company payable to the City of Worcester in the amount of five percent of the trade bid. A trade bid accompanied by any other form of bid deposit than those specified will be rejected.
- C. Trade Sub-Bid Requirements: (None required under this Section.)
- D. Reference Drawings: The Work of this Trade Bid is shown on the following Contract Drawings:
 - 1. 01-GENERAL Series
 - 2. 21-FIRE PROTECTION Series

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. All Work of the following sections:
 - a. 01-GENERAL Series

- b. 21-FIRE PROTECTION Series
 - 2. Firestopping for the Work of this Section, including cutting penetrations and firestopping; complying with requirements specified in Section 07 84 13 - PENETRATION FIRESTOPPING.
 - 3. Core drilling for the Work of this Section.
 - 4. Certified seismic restraints to meet the Commonwealth of Massachusetts Building Code applicable at the time the building permit is issued.
 - 5. Coordination drawings and record drawings and similar requirements.
 - 6. CAMIS excel spreadsheet data collection for Equipment Template and PM Procedure tabs as described in Section 01 77 00 - CLOSEOUT PROCEDURES
 - 7. BIM modeling as specified in this Section and in Section 01 31 29 - COORDINATION DRAWINGS.
- B. Alternates: Not Applicable.
- C. Items to be Installed Only: Not Applicable.
- D. Items to Be Furnished Only: Furnish the following items for installation by the designated Sections:
- 1. Section 03 30 00 – CAST-IN-PLACE CONCRETE:
 - a. Sleeves, anchors, inserts, plates and similar items for fire protection systems.
 - 2. Section 04 20 00 – UNIT MASONRY:
 - a. Access doors in masonry openings.
 - 3. Section 09 29 00 - GYPSUM BOARD ASSEMBLIES:
 - a. Access doors in gypsum board assemblies.
 - 4. Section 09 30 13 - TILING:
 - a. Access doors in tile.
 - 5. Section 09 51 13 - ACOUSTICAL PANEL CEILINGS:
 - a. Access doors in acoustical panel ceilings.
- E. Related Work: The following items are not included in this Section and will be performed under the designated Sections.
- 1. Section 07 84 13 – PENETRATION FIRESTOPPING for coordination of floor and wall penetrations with firestopping contractor.
 - 2. Section 09 29 00 – GYPSUM BOARD ASSEMBLIES for coordination with gypsum ceilings.
 - 3. Section 09 51 13 – ACOUSTICAL PANEL CEILINGS for coordination with acoustical ceilings.
 - 4. Section 23 00 01 – HEATING, VENTILATING AND AIR CONDITIONING for coordination with HVAC piping and ductwork.
 - 5. Section 26 00 01 - ELECTRICAL WORK for fire alarm devices and wiring.
 - 6. Section 31 00 00 – EARTH MOVING for excavation and backfilling, including compacted sand backfill to 12 inches above crown of pipe.
- F. Perform work and provide material and equipment as shown on Drawings and as specified or indicated in this Section of the Specifications. Completely coordinate work of this Section with work of other trades and provide a complete and fully functional installation.

- G. Drawings and Specifications form complimentary requirements; provide work specified and not shown, and work shown and not specified as though explicitly required by both. Although work is not specifically shown or specified, provide supplementary or miscellaneous items, appurtenances, devices and materials obviously necessary for a sound, secure and complete installation.
- H. Give notices, file plans, obtain permits and licenses, pay fees and back charges, and obtain necessary approvals from authorities that have jurisdiction as required to perform work in accordance with all legal requirements and with Specifications, Drawings, Addenda and Change Orders, all of which are part of Contract Documents.

END OF SECTION

SECTION 21 05 00

COMMON WORK RESULTS FOR FIRE SUPPRESSION

(Part of Work of Section 21 00 01 – FIRE PROTECTION, Trade Bid Required)

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.
- B. Sustainable Design Intent: Refer to specification Section 01 81 13 SUSTAINABLE DESIGN REQUIREMENTS for performance and submittal requirements.
- C. Section 01 74 19 "Construction and Demolition Waste Management and Disposal" for disposal of construction, demolition and packaging waste disposal requirements.
- D. Section 01 81 19 "Construction Indoor Air Quality Requirements" for indoor air quality requirements during Construction and for building flush-out or air Quality Testing Requirements, prior to occupancy.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. Grout.
 - 3. Fire-suppression equipment and piping demolition.
 - 4. Equipment installation requirements common to equipment sections.
 - 5. Painting and finishing.
 - 6. Firestopping.
 - 7. Supports and anchorages.

1.3 APPLICABLE CODES AND STANDARDS

- A. The specifications and standards listed below form a part of this section of the specifications. The system shall fully comply with the latest issue, with all updates, of these standards as applicable.
 - 1. Massachusetts State Codes and Regulations:
 - a. 780 CMR Massachusetts State Building Code, 10th edition (MSBC)

- b. 527 CMR Massachusetts Fire Prevention Regulations (MFPR)
 - c. MGL 148 Massachusetts Fire Laws (MFL)
 - d. 521 CMR Massachusetts Architectural Access Board (MAAB) Regulations
 - e. NFPA 70, 2020 Edition, *National Electric Code* as amended by MFPR 12.00
- 2. NFPA Standards
 - a. NFPA 4, Standard for Integrated Fire Protection and Life Safety System Testing, 2015 edition
 - b. NFPA 13, Standard for the Installation of Sprinkler Systems – 2019 edition
 - c. NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water Based Fire Protection Systems, 2015 edition
 - d. NFPA 72, National Fire Alarm and Signaling Code – 2013 edition
- B. In the event of any conflict between these requirements and referenced codes or standards, the specifications shall take precedence. The Boston Fire Department will be the authority having jurisdiction on any and all matters regarding fire protection installations.

1.4 DEFINITIONS

- A. The following are industry abbreviations for organizations:
 - 1. ANSI: American National Standards Institute
 - 2. ASTM: American Society of Testing and Materials
 - 3. NFPA: National Fire Protection Association
 - 4. UL: Underwriters Laboratory
- B. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- C. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- D. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- E. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.
- F. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
- G. Words in the singular shall also mean and include the plural, wherever the context so indicates and words in the plural shall mean the singular, wherever the context so indicates.

- H. Wherever the terms "shown on drawings" are used in the specifications, they shall mean "noted", "indicated", "scheduled", "detailed", or any other diagrammatic or written reference made on the drawings.
- I. Wherever the term "provide" is used in the specifications it will mean "furnish" and "install", "connect", "apply", "erect", "construct", or similar terms, unless otherwise indicated in the specifications.
- J. Wherever the term "material" is used in the specifications it will mean any "product", "equipment", "device", "assembly", or "item" required under the Contract, as indicated by trade or brand name, manufacturer's name, standard specification reference or other description.
- K. The terms "approved", or "approval" shall mean the written approval of the Engineer. These terms do not relieve The Fire Suppression Contractor from the requirements of the contract documents.
- L. The term "specification" shall mean all information contained in the bound or unbound volume, including all "Contract Documents" defined therein, including all drawings.
- M. The terms "directed", "required", "permitted", "ordered", "designated", "prescribed" and similar words shall mean the direction, requirement, permission, order, designation or prescription of the Engineer. The terms "approved", "acceptable", "satisfactory" and similar words shall mean approved by, acceptable or satisfactory to the Engineer. The terms "necessary", "responsible", "proper", "correct" and similar words shall mean necessary, reasonable, proper or correct in the judgment of the Engineer.
- N. "Concealed" means hidden from sight in chases, furred spaces, shafts, hung ceilings, embedded in construction or in crawl spaces.
- O. "Exposed" means not installed underground or "concealed" as defined above.
- P. "Contractor or Sprinkler Contractor or Fire Suppression Contractor" refers to the Contractor and/or his Subcontractors responsible for furnishing and installing all of the work indicated in the Fire Suppression System Specifications and as shown on the contract drawings.
- Q. "Owner" shall refer to the Massachusetts Institute of Technology and "Engineer" shall refer to Arup.
- R. "NPS" shall refer to nominal pipe size.
- S. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.
- T. High-Pressure Piping System Component: Listed for 300-psig minimum working pressure.

1.5 PERFORMANCE REQUIREMENTS

- A. The Contractor shall furnish and install fire suppression system materials that are "Approved," "Identified" "Labeled," and "Listed" by a Nationally Recognized Testing Laboratory (NRTL) as suitable for the intended use. Any equipment and materials that are not NRTL "Approved," "Identified", "Labeled", and "Listed" that is installed by the contractor shall be removed and replaced at the contractor's expense.
- B. Each component of the fire suppression system shall be listed in accordance with the applicable code or standard as a compatible product of manufacturer under the appropriate category by Underwriters' Laboratories, Inc. (UL), and shall bear the "UL" label and be FM Approved for the intended use.
- C. All equipment and components shall be new, and the manufacturer's current model. The materials, appliances, equipment and devices shall be tested and listed for use as part of a fire suppression system. The contractor shall be responsible for the satisfactory installation of the complete system.
- D. The specifications identified within Division 21 identify the essential functional requirements of the fire suppression system. Each manufacturer's equipment shall comply with or exceed the functional intent of this specification. Any proposed deviations from these specifications must be approved and documented. Documentation must include identification of the proposed deviation and specific acceptance of the deviation by the Owner and Engineer.
- E. Each component of the fire suppression system shall be UL listed and FM approved. All components shall be installed in accordance with their specific listing and/or approval criteria. All equipment shall be installed in accordance with the manufacturer's recommendations and requirements.
- F. Installation shall be in accordance with the applicable edition and provisions of the equipment manufacturer's guidelines.
- G. Provide clean-up, painting and patching to match existing conditions. Restore walls and ceilings to original condition prior to completing work. The project will not be considered complete until all site conditions are accepted by the owner and the Engineer.
- H. All penetrations shall be provided in a workman like manner.
- I. The extent of the system work is mostly shown on the Contract Drawings and contained in the Specifications. Contract Drawings diagrammatic and indicate general arrangement of systems and work included. The Specifications supplement the drawings and include items of work which are not detailed on the drawings. Submission of a proposal shall be evidence that the contractor has reviewed all of the Contract Documents and performed all necessary visits to determine the complete scope of work.
- J. The Fire Suppression Contractor is directed to examine all contract drawings in detail. Failure of the Fire Suppression Contractor to examine all areas, which may

require special considerations and misinterpretation of the contract documents resulting there from, shall be entirely their responsibility.

- K. The system shall be installed mostly as shown on the Contract Documents with design criteria as specified in this Section. This specification requires the Contractor to prepare and submit drawings, system schematics and any other documents needed for the procurement of approvals and the provision of a complete, functional and approved system. As a result, the Contract Drawings serve the purpose of indicating design criteria for the Contractor's use and guidance in preparing the required submittal documents for review.
- L. The contract drawings and specifications form complimentary requirements. Provide work specified and not shown, and work shown and not specified as though explicitly required by both. Although work is not specifically shown or specified, provide supplementary or miscellaneous items, appurtenances, devices and materials necessary for a sound, secure, complete and approved installation, to include any and all FM Global recommendations. Completely coordinate work of this specification with work of other trades.
- M. The Contractor is directed to bring to the attention of the Engineer, in writing, any discrepancies, deficiencies and/or other matters as they may relate to existing conditions, codes, standards, recommendations and/or job conditions. Failure of the Contractor to do so prior to bidding shall indicate acceptance of all documents herein and all job conditions.
- N. The Contractor shall bring to the attention of the Engineer any conflicts between these drawings and codes or standards for resolution. The Contractor shall not discuss these matters with Building or Fire Official without the approval of the Engineer.
- O. Should the Contractor perform any work that does not comply with the requirements of the specifications, drawings and applicable codes, standards and references, the Contractor shall bear all costs arising in correcting the work to the satisfaction of the Engineer and owner.
- P. The Contractor shall also include costs for startup, pre-testing and acceptance testing, for making all the systems fully operational, for providing all warranties and design contingencies, to include filling and refilling the diesel tank.
- Q. Provide contract cost breakdown in accordance with other sections of this specification and submit a breakdown of material and labor costs to Engineer.
- R. The Contractor shall be required to prepare detailed stamped and certified shop drawings and hydraulic calculations as specified within the Division 21 sections. This information, in the form of a single "Package", shall be submitted to the Engineer for review prior to fabrication and installation. The "Package" shall bear UL Listing and FM Global Approval.
- S. Give all notices, file all plans and other documents, obtain all permits and all licenses, pay all fees and obtain all approvals from all Authorities Having Jurisdiction as required to perform work in accordance with all requirements and with the

Specifications and Contract Drawings, all of which are considered a part of these Contract Documents

1.6 SUBMITTALS

A. General Submittal Requirements:

1. All submittals shall be provided in a neat and organized manner. Both hard copies and electronic versions of the submittals shall be provided. Where data sheets are submitted, they shall be properly annotated to indicate the correct model and make for the product being submitted.
2. Before any work is commenced, the submittal must be reviewed and accepted by the Engineer for conformance with the design intent and information provided in the contract documents.
3. Submittals shall be reviewed and accepted by the Engineer prior to submitting documentation to the authorities.
4. All submittals shall comply with the Owner's administrative and procedural requirements.
5. Electronic submittals shall be in PDF format. The files shall be organized so that the order of the electronic submission matches the hard copy.

B. Product Data: Provide product information of all equipment proposed to be utilized on this project.

1. Product data shall include the manufacturer's published data sheets and installation instructions.
2. Documentation shall include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Product data shall be the current published version. Superseded, out dated, and draft versions will not be accepted.
4. Annotate to indicate the model, type, and size of each item. Where more than one model is included on the documents, the contractor shall clearly indicate which model is being submitted. If the model is not clearly marked, the equipment submittal may be rejected.

C. Drawings:

1. Drawings shall be on uniform size sheets.
2. Coordination drawings will not be accepted in lieu of working plans.
3. All working plans shall be signed and stamped by a registered Professional Engineer. Drawings shall be sealed if required by their license.
4. Shop drawings shall comply with 780 CMR requirements for Tier Two documentation. Shop drawings shall be identified as "Tier Two Shop Drawings." Shop drawings shall note the name(s), license number(s), and license expiration date(s) of the contractor(s) installing the fire protection systems.
5. Record drawings shall comply with 780 CMR requirements for Tier Three documentation.
6. Coordination drawings shall be provided for review of sprinkler scope with building systems, structure and architect.

D. Calculations:

1. Submit input file(s) used for all calculations completed with commercially available software.
2. Provide calculations in hard copy and electronic format.
3. All calculations shall be signed and stamped by a registered Professional Engineer.

E. Qualification Data: For qualified Installer.

F. Welding certificates.

G. Fire-hydrant flow test report.

H. Field quality-control reports.

I. Provide As-builts, Operation & Maintenance Manual, and Contractor Material & Test certificates.

1.7 HYDRANT FLOW TEST

- A. The contractor shall be required to perform a hydrant water flow test as part of this contract that will establish the available water supply capacity for the sprinkler system. The water supply test shall establish the available flow and pressure at the point of connection to the building sprinkler system. The results of the contractor's hydrant flow test shall be utilized for all system design including final fire pump size selection. Obtain all permits, and notify the owner and owner's representative no fewer than 3 days prior to the scheduled date of testing. Contractor shall bear all costs associated with conducting the hydrant flow test(s).
- B. Perform hydrant flow test according to NFPA 13, and NFPA 291. Use results for system design calculations.
- C. Report test results promptly and in writing.

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. 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. Shop drawings and hydraulic calculations shall be stamped by a qualified professional engineer.

2. The fire suppression system contractor shall provide proof of competence for both the company and the individual assigned to this project by providing documented related experience in terms of installing similar fire suppression systems for a period of not less than three years which is deemed acceptable to the owner's representative.
- B. Steel Pipe Grooves: The contractor shall certify that all pipe grooves are in compliance with all applicable standards and coupling manufacturer requirements. Each pipe segment that is grooved (onsite and offsite) shall be identified with a distinct number that is visible with the naked eye from the floor level 10 ft below. An active data base shall be maintained and submitted certifying each groove is in compliance. The data base shall minimally include the corresponding pipe number, permitted groove tolerances, actual groove measurements, or approved equivalent documentation such as photo documentation. The format of the data base shall be submitted and approved by the owner and engineer prior to any pipe fabrication. The contractor will be expected to demonstrate onsite that grooves are in compliance. Demonstration may include the removal of selected couplings onsite and demonstrate compliance with coupling manufacturer's recommended pipe diameter tape. Contractor shall be responsible for having a Victaulic pipe diameter tape onsite at all times. Utilize Victaulic PT100A or equivalent.
 - C. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
 - D. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
 - E. 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. Electrical Characteristics for Fire-Suppression Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.
 - G. The contractor shall be responsible for maintaining onsite hard copies of the following NFPA standards of the editions identified in section 1.3:
 1. NFPA 13, Standard for the Installation of Sprinkler Systems.
 2. NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water Based Fire Protection Systems.

1.9 PROJECT CONDITIONS

- A. Interruption of Existing Fire-Suppression Sprinkler and Standpipe Service: Do not interrupt fire-suppression standpipe service to facilities occupied by Owner or others unless permitted under the following conditions.
 - 1. Notify the Owner no less than one week in advance of proposed interruption of fire-suppression standpipe service.
 - 2. Notify local fire department of impairment no less than one week in advance of proposed interruption of fire-suppression standpipe service.
 - 3. Do not proceed with interruption of fire-suppression standpipe service without Owner's written permission.
- B. Firestopping Environmental Limitations: Do not install penetration firestopping when ambient or substrate temperatures are outside limits permitted by penetration firestopping manufacturers or when substrates are wet because of rain, frost, condensation, or other causes.
 - 1. Install and cure penetration firestopping per manufacturer's written instructions using natural means of ventilations or, where this is inadequate, forced-air circulation.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. 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.
- B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.11 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for fire-suppression installations.
- B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- C. Coordinate requirements for access panels and doors for fire-suppression items requiring access that are concealed behind finished surfaces.

1.12 WARRANTY

- A. The installation shall be warranted for a period of one year. Service on the system or replacement of defective parts shall be provided at no expense to the Owner during this warranty period. The warranty period shall begin the day the fire suppression system is approved and accepted by the Owner. Owner's acceptance will be when

the system is installed and tested, (as witnessed by the Owner and Engineer), accepted by the Authority Having Jurisdiction, and the Owner has received all necessary documentation.

PART 2 - PRODUCTS

2.1 GENERAL

2.2 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.
 2. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.3 PIPE, TUBE, AND FITTINGS

- A. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.4 JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
 2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

2.5 GROUT

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - 1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.
 - 3. Packaging: Premixed and factory packaged.

2.6 PENETRATION FIRESTOPPING

- A. Provide UL listed and FM approved firestopping for penetrations through rated assemblies in accordance with specification section "07 84 13 - Penetration Firestopping."

PART 3 - EXECUTION

3.1 GENERAL

- A. Permits required by the Authority Having Jurisdiction shall be issued prior to commencing work related to that permit. All costs associated with obtaining permits shall be borne by the contractor.
- B. Prior to connecting any new fire protection system or equipment to the existing mains and standpipes, the existing fire protection mains and standpipes shall be flushed in accordance with NFPA 14 and NFPA 24.
 - 1. The flush flow rate shall be a minimum of 390 gpm for 4 inch, 880 gpm for 6 inch and 1,560 gpm for 8 inch.
 - 2. The flow rate shall be sustained until the water is clear and as indicated by no collection of foreign material in burlap bags at the outlets.
- C. Complete a hydrostatic test of all existing system piping after all new connections have been completed to the existing standpipe system.

3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 21 Sections specifying piping systems.
- B. 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.

- C. Install piping in exposed locations, unless otherwise indicated, or if an existing acoustical ceiling tile ceiling is in place.
- 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 to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials.
- M. Verify final equipment locations for roughing-in.
- N. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.
- O. The contractor shall install piping in a manner as practical as possible to allow complete system drainage from the system's or zone's main drain valve. Trapped sections of pipe should be avoided where possible. Where trapped sections of piping cannot be avoided, auxiliary drains shall be provided in accordance with NFPA 13. All auxiliary drain locations shall be identified on the as-built drawings. All auxiliary drains shall be equipped with a valve, hose connection and shall be plugged or capped.

3.3 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 21 Sections specifying piping systems joint construction.
- 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 pipe 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 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. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.4 PROTECTION OF PIPING AGAINST DAMAGE WHERE SUBJECT TO EARTHQUAKES

- A. The seismic design category of the building classified as category C. The criteria as indicated within NFPA 13 section 18 "Protection of Piping Against Damage Where Subject to Earthquakes." The following minimum criteria shall be provided on all fire protection system piping 2.5-inches and larger:
 - 1. Lateral seismic bracing shall be provided in accordance with section 18 of NFPA 13. In no case shall lateral bracing be spaced farther than 40 ft on center. The distance from the last brace to the end of the pipe shall not exceed 6 ft.
 - 2. Longitudinal seismic bracing shall be provided in accordance with section 18 of NFPA 13. In no case shall longitudinal bracing be spaced farther than 80 ft on center. The distance from the last brace to the end of the pipe shall not exceed 40 ft.
 - 3. A listed seismic separation assembly consisting of flexible piping in accordance with NFPA 13 section 18 shall be provided where piping crosses seismic separation assemblies. Refer to architectural and structural drawings for all locations of seismic separation assemblies (not all locations may be directly indicated on the fire protection contract documents; the contractor is responsible for coordinating with all required locations). A four-way seismic brace shall be provided within 6-ft upstream and downstream of the seismic separation assembly. Piping smaller than 2.5-inches in size where crossing seismic separation assemblies shall be equipped with flexible couplings installed within 24-inches of the seismic separation assembly. Note that for piping smaller than 2.5-inches in size; these locations where building seismic separation assemblies exist; shall take precedence over the requirements for threaded fittings where otherwise indicated within the fire protection specifications.
 - 4. Sway bracing of risers shall be provided in accordance with section 18 of NFPA 13.
 - 5. Clearance around all piping extending through walls, floors, platforms and foundations including drains, fire department connections and other auxiliary

- piping shall be provided or equivalent means of clearance provided in accordance with section 18 of NFPA 13.
6. Flexible couplings shall be installed in accordance with section 18 of NFPA 13. Piping systems having more flexible couplings installed other than as indicated in section 18 of NFPA 13 shall have seismic bracing installed within 24-inches of the flexible coupling(s).
 7. All piping regardless of size shall be equipped with flexible couplings installed within 24-inches of building expansion joints. All piping regardless of size where flexible couplings have been installed within 24-inches of building expansion joints shall have seismic bracing installed within 24-inches of the flexible couplings. Refer to architectural and structural drawings for all locations of building expansion joints (not all locations may be directly indicated on the fire protection contract documents; the contractor is responsible for coordinating wall all required locations). Note that for piping smaller than 2.5-inches in size; these locations where building expansion joints exist, shall take precedence over the requirements for threaded fittings where otherwise indicated within the fire protection specifications.
 8. Fasteners and supports of seismic bracing shall comply with NFPA 13 section 18.
 9. Hangers shall comply with section 18 of NFPA 13.
 10. Restraint of branch lines smaller than 2.5-inches shall not be required.
 11. All locations of seismic bracing (lateral & longitudinal, riser sway assemblies, seismic separation assemblies and all flexible coupling locations) shall be clearly indicated on the fire protection shop drawings and working plans.

3.5 PAINTING

A. Preparation

1. Comply with manufacturer's written instructions and recommendations in "MPI Manual" applicable to substrates indicated.
2. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.
 - a. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.
3. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.

B. Application:

1. Apply paints according to manufacturer's written instructions and to recommendations in "MPI Manual."
 - a. Use applicators and techniques suited for paint and substrate indicated.
 - b. Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed equipment or furniture with prime coat only.

- c. Paint front and backsides of access panels, removable or hinged covers, and similar hinged items to match exposed surfaces.
 - d. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
 - e. Primers specified in painting schedules may be omitted on items that are factory primed or factory finished if acceptable to topcoat manufacturers.
- 2. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.
- 3. Painting Fire Suppression, Plumbing, HVAC, Electrical, Communication, and Electronic Safety and Security Work. Paint the following work where exposed:
 - a. Uninsulated metal piping.
 - b. Uninsulated plastic piping.
 - c. Pipe hangers and supports.
 - d. Metal conduit.
- C. Cleaning and Protection
 - 1. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.
 - 2. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.
 - 3. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Engineer, and leave in an undamaged condition.
 - 4. Protect and replace any sprinkler that is painted with a finish that was not applied at the factory.
 - 5. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.
- D. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 PENETRATION FIRESTOPPING INSTALLATION

- A. Preparation: Prepare surfaces and substrates as recommended by the manufacturer using that manufacturer's recommended products and methods.
- B. Masking Tape: Use masking tape to prevent penetration firestopping from contacting adjoining surfaces that will remain exposed on completion of the Work and that would otherwise be permanently stained or damaged by such contact or by cleaning methods used to remove stains. Remove tape as soon as possible without disturbing firestopping's seal with substrates.
- C. General: Install penetration firestopping to comply with manufacturer's written installation instructions and published drawings for products and applications indicated.

- D. Cleaning and Protection: Clean off excess fill materials adjacent to openings as the Work progresses by methods and with cleaning materials that are approved in writing by penetration firestopping manufacturers and that do not damage materials in which openings occur.

3.7 VALVE AND SPECIALTIES INSTALLATION

- A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to the following requirements and Division 21 sections specifying valve and specialties installation.
- B. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.
- C. 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.
- D. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.
- E. Install Butterfly Valves designed to be Supervised Closed as indicated on the drawings or for fire pump test headers, roof manifold valves or other valves intended to remain normally closed. These valves shall not be installed where water flow is required for normal system operation.
- F. All sprinkler control valves are required to be installed with locks and chains in addition to electrical supervision. The contractor will be required to provide the chains and install the locks provided by Owner. The chains provided by the contractor shall be 1/8" for small butterfly valves (3" and smaller) and 3/16" for larger OS&Y valves and butterfly valves (4" and larger).
- G. All control valves capable of impairing a portion of the fire protection service such as control valves installed as part of a floor control assembly; shall be installed such that the centerline of the operating handle is located no more than 7 ft above the finished floor. If a valve is required to be located above 7 ft, then it shall be equipped with an integral chain and capable of being operated at floor level.
- H. Control valves shall not be located above ceilings.

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 05 Section "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor fire-suppression materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.9 GROUTING

- A. Mix and install grout for fire-suppression equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases and provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout.

3.10 PROTECTION OF OPEN PIPE ENDS DURING CONSTRUCTION

- A. During construction means shall be provided to prevent entry of foreign material into the piping system. Pipe that is not being actively worked on, shall be plugged or capped with approved materials. The use of tape on pipe ends or similar methods shall not be acceptable to prevent foreign material entry.

3.11 TESTING

- A. The contractor shall be responsible to support functional testing as necessary of all required interfaces of the fire protection system with other trades and in accordance with NFPA 4. The contractor shall support all required testing during both fire alarm first party and third party testing efforts. This may include but is not limited to the following:
 - 1. Support testing of flow switches, pressure switches and supervisory switches throughout the building.
 - 2. Support functional testing including the operation of alarm check valves, dry-pipe, and preaction valves.
 - 3. Support water delivery functional testing efforts to the remote inspector's test connection for dry-pipe and preaction valves.
- B. In addition to the testing requirements as indicated above or within other Division 21 sections, the contractor shall be responsible for supporting and conducting additional tests for any portion of the fire protection system as specified herein or as indicated on the contract documents at the request of the owner, engineer or authority having jurisdiction. Factory authorized service representatives shall be made available to demonstrate and conduct additional testing as required. The contractor should assume that separate demonstration for all fire protection equipment and systems will be required for the owner/engineer and authority having jurisdiction.

END OF SECTION

SECTION 21 05 17

SLEEVES AND SLEEVE SEALS FOR FIRE-SUPPRESSION PIPING

(Part of Work of Section 21 00 01 – FIRE PROTECTION, Trade Bid Required)

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.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings:
 - 1. Layouts indicating locations of all sleeves used in fire protection systems.

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. 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Smith, Jay R. Mfg. Co.
 - 2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.
 - 3. Mifab
 - 4. Or approved equal
- 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

SLEEVES AND SLEEVE SEALS FOR FIRE SUPPRESSION PIPING

1. Advance Products & Systems, Inc.
 2. CALPICO, Inc.
 3. Metraflex Company (The).
 4. Pipeline Seal and Insulator, Inc.
 5. Proco Products, Inc.
 6. Or approved equal
- 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 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. Presealed Systems.
 2. Unique Firestop
 3. SpecSeal
 4. Or approved equal
- 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.

2.5 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 galvanized-steel-sheet 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 07 92 00 "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 07 84 13 "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 07 62 00 "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 07 84 13 "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. Using grout, 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.

3.6 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
- B. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls above Grade:
 - a. Cast-iron wall sleeves

2. Exterior Concrete Walls below Grade:
 - a. Cast-iron 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.
 - 2) Concrete Slabs-on-Grade:
 - b. Cast-iron 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 above Grade:
 - a. Galvanized-steel-pipe sleeves
4. Interior Partitions:
 - a. All pipe sizes: Galvanized-steel-sheet sleeves

END OF SECTION

SECTION 21 05 18

ESCUTCHEONS FOR FIRE-SUPPRESSION PIPING

(Part of Work of Section 21 00 01 – FIRE PROTECTION, Trade Bid Required)

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. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
- D. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.
- E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

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. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge or split-plate, stamped-steel type with exposed-rivet hinge.
- c. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge or split-plate, stamped-steel type with exposed-rivet hinge.
- d. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge or split-plate, stamped-steel type with exposed-rivet hinge.

- e. Bare Piping in Equipment Rooms: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge or split-plate, stamped-steel type with exposed-rivet hinge.
- 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 or split-casting, floor-plate type.

3.2 FIELD QUALITY CONTROL

- A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION

SECTION 21 05 29

HANGERS AND SUPPORTS FOR FIRE SUPPRESSION PIPING AND EQUIPMENT

(Part of Work of Section 21 00 01 – FIRE PROTECTION, Trade Bid Required)

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. Metal framing systems.
4. Fastener systems.
5. Equipment supports.

B. Related Requirements:

1. Section 05 50 00 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 21 05 48 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" for vibration isolation devices and seismic restraints.

HANGERS AND SUPPORTS FOR FIRE SUPPRESSION PIPING AND EQUIPMENT

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. 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. 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 trapeze hangers.
 - 2. Include design calculations for designing trapeze hangers.

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 01 40 00 "Quality Requirements," to design trapeze pipe hangers and equipment supports.
- B. Structural Performance: Hangers and supports for fire-suppression 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.
 - 3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.
- C. NFPA Compliance: Comply with NFPA 13 requirements.
- D. UL Compliance: Comply with UL 203.
- E. FM Global Compliance: Comply with all applicable FM Global datasheets.

2.2 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 - 1. Description: Factory-fabricated components, NFPA approved, UL listed, and FM approved for fire-suppression piping support.
 - 2. Galvanized Metallic Coatings: Pregalvanized or hot-dip galvanized.
 - 3. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.

- B. Copper Pipe and Tube Hangers:

HANGERS AND SUPPORTS FOR FIRE SUPPRESSION PIPING AND EQUIPMENT

1. Description: Copper-coated-steel, factory-fabricated components, NFPA approved, UL listed, and FM approved for fire-suppression piping support.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel or stainless 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 NFPA-approved, UL-listed, and FM-approved carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 METAL FRAMING SYSTEMS

- A. MFMA Manufacturer Metal Framing Systems:
 1. Description: Shop- or field-fabricated pipe-support assembly, made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
 2. Standard: Comply with MFMA-4, factory-fabricated components for field assembly.
 3. Channels: Continuous slotted carbon-steel channel with inturned lips.
 4. Channel Width: Selected for applicable load criteria.
 5. Channel Nuts: Formed or stamped 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.

2.5 FASTENER SYSTEMS

- A. Mechanical-Expansion Anchors: NFPA-approved, UL-listed, and FM-approved, 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.

HANGERS AND SUPPORTS FOR FIRE SUPPRESSION PIPING AND EQUIPMENT

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. B-line; Eaton, Electrical Sector.
 - b. Empire Tool and Manufacturing Co., Inc.
 - c. Hilti, Inc.
 2. Indoor Applications: Zinc-coated or Stainless steel.
 3. Outdoor Applications: Stainless steel.
- B. Fasteners to CLT: Minimum 1/4" diameter SWG ASSY 3/0 wood screw x 3-1/2" length spaced no closer than 3" o.c. and no closer than 6" from all edges. Max allowable load per screw to equal 200 lb.
1. Manufacturers:
 - a. Myticon Timber Connectors Inc.
 - b. Simpson Strong-Tie
 - c. Eaton
 - d. Approved equal

2.6 EQUIPMENT SUPPORTS

- A. Description: NFPA-approved, UL-listed, and FM-approved, welded, shop- or field-fabricated equipment support, made from structural-carbon-steel shapes.

2.7 MATERIALS

- A. Aluminum: ASTM B221.
- 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.

HANGERS AND SUPPORTS FOR FIRE SUPPRESSION PIPING AND EQUIPMENT

- 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, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with requirements in Section 07 84 13 "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 installation requirements of approvals and listings. 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 strut systems.

HANGERS AND SUPPORTS FOR FIRE SUPPRESSION PIPING AND EQUIPMENT

D. Fastener System Installation:

1. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions. Install in accordance with approvals and listings.

E. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.

F. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

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. 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.

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.

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.

HANGERS AND SUPPORTS FOR FIRE SUPPRESSION PIPING AND EQUIPMENT

3.4 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.

3.5 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: Cleaning and touchup painting of field welds, bolted connections, and abraded, shop-painted areas on miscellaneous metal are specified in Section 09 91 23 "Interior Painting." or Section 09 96 00 "High-Performance Coatings."
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

HANGERS AND SUPPORTS FOR FIRE SUPPRESSION PIPING AND EQUIPMENT

3.7 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with NFPA and FM Global requirements 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 attachments for general service applications.
- F. Use stainless-steel pipe hangers and attachments for hostile environment applications.
- G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
- H. Horizontal-Piping Hangers and Supports: Comply with NFPA and FM Global requirements. 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. Steel Pipe Clamps (MSS Type 4): For suspension of NPS 1/2 to NPS 24 if little or no insulation is required.
 - 3. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
 - 4. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
 - 5. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
 - 6. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.

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7. 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.
 8. 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.
 9. 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.
- I. 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.
- J. Hanger-Rod Attachments: Comply with NFPA and FM Global requirements.
- K. Building Attachments: Comply with NFPA and FM Global requirements. 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. C-Clamps (MSS Type 23): For structural shapes.
 3. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
- L. Saddles and Shields: Comply with NFPA and FM Global requirements. 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.

HANGERS AND SUPPORTS FOR FIRE SUPPRESSION PIPING AND EQUIPMENT

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.
- M. Comply with NFPA and FM Global requirements for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- N. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

END OF SECTION

SECTION 21 05 48

VIBRATION AND SEISMIC CONTROLS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

(Part of Work of Section 21 00 01 – FIRE PROTECTION, Trade Bid Required)

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 includes the following:
 - 1. Isolation pads.
 - 2. Isolation mounts.
 - 3. Restrained elastomeric isolation mounts.
 - 4. Restraining braces.

1.3 APPLICABLE CODES AND STANDARDS

- A. The specifications and standards listed below form a part of this section of the specifications. The system shall fully comply with the latest issue, with all updates, of these standards as applicable. Where these standards conflict with other specified requirements, the most restrictive requirement shall govern.
 - 1. Massachusetts State Codes and Regulations:
 - a. 780 CMR Massachusetts State Building Code, 10th edition (MSBC)

- b. 527 CMR Massachusetts Fire Prevention Regulations (MFPR)
- c. MGL 148 Massachusetts Fire Laws (MFL)
- d. 2021 International Mechanical Code (IMC) as amended by MSBC 28

2. NFPA Standards

- a. NFPA 13, Standard for the Installation of Sprinkler Systems – 2019 edition
- b. NFPA 14, Standard for the Installation of Standpipe and Hose Systems – 2019 edition
- c. NFPA 24, Standard for the Installation of Private Service Mains and Their Appurtenances – 2019 edition
- d. NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water Based Fire Protection Systems, 2020 edition

1.4 DEFINITIONS

- A. AASHTO: American Association of State Highway and Transportation Officials
- B. ICC-ES: ICC Evaluation Service.
- C. OSHA: Occupational Safety and Health Administration

1.5 PERFORMANCE REQUIREMENTS

- A. Seismic-Restraint Loading:
 - 1. Site Class as Defined in 780 CMR: D
 - 2. Assigned Seismic Use Group or Building Category as Defined in 780 CMR: C.
 - a. Component Importance Factor: 1.5
 - b. Component Response Modification Factor: 3 in accordance with ASCE/SEI 7-05.
 - 3. Design Spectral Response Acceleration at Short Periods (0.2 Second): in accordance with 780 CMR and ASCE/SEI 7-05.
 - 4. Design Spectral Response Acceleration at 1-Second Period: (0.069) in accordance with 780 CMR and ASCE/SEI 7-05.

1.6 ACTION SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
 - a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction.
 - b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details 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. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators, seismic restraints, and for designing vibration isolation bases.
2. Seismic-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - c. Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.7 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For professional engineer and testing agency.
- B. Welding certificates.

1.8 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
- B. Comply with seismic-restraint requirements in 780 CMR and NFPA 13 unless requirements in this Section are more stringent.
- C. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval by ICC-ES or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Ace Mountings Co., Inc.
 - 2. Amber/Booth Company, Inc.
 - 3. California Dynamics Corporation.

4. Isolation Technology, Inc.
 5. Kinetics Noise Control.
 6. Mason Industries.
 7. Vibration Eliminator Co., Inc.
 8. Vibration Isolation.
 9. Vibration Mountings & Controls, Inc.
 10. Or approved equal
- B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
1. Resilient Material: Oil- and water-resistant
- C. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.
1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
- D. Restrained Mounts: All-directional mountings with seismic restraint.
1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
 2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

2.2 SEISMIC-RESTRAINT DEVICES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Amber/Booth Company, Inc.
 2. California Dynamics Corporation.
 3. Cooper B-Line, Inc.; a division of Cooper Industries.
 4. Hilti, Inc.
 5. Kinetics Noise Control.
 6. Loos & Co.; Cableware Division.
 7. Mason Industries.
 8. TOLCO Incorporated; a brand of NIBCO INC.
 9. Unistrut; Tyco International, Ltd.
 10. Or approved equal
- B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction.
1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
- C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with 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; and rated in tension, compression, and torsion forces.
- D. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod.

- E. 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.
- F. 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.
- G. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
- H. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.
- I. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.3 FACTORY FINISHES

- A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
 - 1. Powder coating on springs and housings.
 - 2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
 - 3. Baked enamel or powder coat for metal components on isolators for interior use.
 - 4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.
- 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 by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction.
- B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

- A. Equipment Restraints:
 - 1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
 - 2. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction providing required submittals for component.
- B. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127 and NFPA 13.

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 .
- C. Install cables so they do not bend across edges of adjacent equipment or building structure.
- D. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES or an agency acceptable to authorities having jurisdiction providing required submittals for component.
- E. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- F. 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.
- G. 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.
- H. Drilled-in 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 the 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. Wedge Anchors: 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 Anchors: 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 SEISMIC MOTION

- A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 21 13 13 "Wet-Pipe Sprinkler and Standpipe Systems" and Section 21 13 16 "Dry-Pipe Sprinkler Systems" for piping flexible connections.

END OF SECTION

SECTION 21 05 53

IDENTIFICATION FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

(Part of Work of Section 21 00 01 – FIRE PROTECTION, Trade Bid Required)

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. Valve tags.
 - 5. 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 and the proposed content for each label.
- D. Valve Schedules: Valve numbering scheme.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For each piping system to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:

- 1. Material and Thickness: Brass, 0.032 inch stainless steel, 0.025 inch aluminum, 0.032 inch with predrilled holes for attachment hardware.
- 2. Letter Color: White.
- 3. Background Color: Red.
- 4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- 5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than, 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-fourths the size of principal lettering.
- 6. Fasteners: Stainless-steel rivets or self-tapping screws.
- 7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

- B. Plastic Labels for Equipment:

- 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, with predrilled holes for attachment hardware.

2. Letter Color: White.
 3. Background Color: Red.
 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
 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-fourths the size of principal lettering.
 7. Fasteners: Stainless-steel rivets or self-tapping screws.
 8. 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. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, with predrilled holes for attachment hardware.
- B. Letter Color: Red.
- C. Background Color: White.
- D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

- F. 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-fourths the size of principal lettering.
- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- 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. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service and showing flow direction. Any pipe labels used on CPVC piping shall be compatible with the piping.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe-Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; 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 1-1/2 inches high.
- E. Pipe-Label Colors:
 - 1. Background Color: Red.
 - 2. Letter Color: White.

2.4 VALVE TAGS

- A. 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 thick, with predrilled holes for attachment hardware.
 - 2. Fasteners: Brass wire-link chain or S-hook.
 - 3. Valve-Tag Color: Red.
 - 4. Letter Color: White.
- B. 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. Warning Tags: 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: 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 LABEL INSTALLATION

- 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 or permanently fasten labels on each major item of mechanical equipment.
- D. Locate equipment labels where accessible and visible.
- E. Piping Color-Coding: Painting of piping is specified in Section 09 91 23 "Interior Painting." or Section 09 96 00 "High-Performance Coatings."
- F. 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. 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.

3.3 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems. List tagged valves in a valve-tag schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and with captions similar to those indicated in "Valve-Tag Size and Shape" Subparagraph below:
 1. Valve-Tag Size and Shape:
 - a. Dry Fire-Suppression Standpipe: 1-1/2 inches, round.
 - b. Wet-Pipe Sprinkler System: 1-1/2 inches, round.
 - c. Dry-Pipe Sprinkler System: 1-1/2 inches, round.

3.4 WARNING-TAG INSTALLATION

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

END OF SECTION

SECTION 21 13 13

WET-PIPE SPRINKLER AND STANDPIPE SYSTEMS

(Part of Work of Section 21 00 01 – FIRE PROTECTION, Trade Bid Required)

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. Fire-protection valves.
- 3. Hose connections
- 4. Fire-department connections.
- 5. Forward-flow test header.
- 6. Sprinklers.
- 7. Alarm devices.
- 8. Manual control stations.
- 9. Control panels.
- 10. Pressure gages.

11. Pressure reducing valves.

B. Related Sections:

1. Section 21 05 17 "Sleeves and sleeve seals for fire-suppression piping."
2. Section 21 05 18 "Escutcheons for fire-suppression piping"
3. Section 21 05 53 "Identification for fire-suppression piping and equipment"
4. Section 28 31 11 "Digital, addressable fire-alarm system"

1.3 APPLICABLE CODES AND STANDARDS

- A. The specifications and standards listed below form a part of this section of the specifications. The system shall fully comply with the latest issue, with all updates, of these standards as applicable. Where these standards conflict with other specified requirements, the most restrictive requirement shall govern.

1. Massachusetts State Codes and Regulations:

- a. 780 CMR Massachusetts State Building Code, 10th edition (MSBC) (International Building Code, 2023 Edition, as amended)
- b. 527 CMR Massachusetts Fire Prevention Regulations (MFPR) (NFPA 1, 2021 Edition, as amended)
- c. MGL 148 Massachusetts Fire Laws (MFL)
- d. 521 CMR Massachusetts Architectural Access Board (MAAB) Regulations
- e. NFPA 70, 2023 Edition, *National Electric Code* as amended by MFPR 12.00
- f. 2021 International Mechanical Code (IMC) as amended by MSBC 28
- g. 2021 International Energy Conservation Code & Stretch Energy Code

2. NFPA Standards

- a. NFPA 13, Standard for the Installation of Sprinkler Systems – 2019 edition
- b. NFPA 14, Standard for the Installation of Standpipe and Hose Systems – 2021 edition

- c. NFPA 20, Standard for the Installation of Stationary Pumps for Fire Protection – 2019 edition
- d. NFPA 24, Standard for the Installation of Private Service Mains and Their Appurtenances – 2019 edition
- e. NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water Based Fire Protection Systems, 2019 edition
- f. NFPA 72, National Fire Alarm and Signaling Code – 2019 edition

1.4 DEFINITIONS

- A. High-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure higher than standard 175 psig, but not higher than 300 psig.
- B. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175 psig maximum.

1.5 SYSTEM DESCRIPTIONS

- A. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device. Hose connections are included if indicated.

1.6 PERFORMANCE REQUIREMENTS

- A. The automatic sprinkler system shall be designed in accordance with all required and recommended provisions of NFPA 13, manufacturer requirements and recommendations and Massachusetts State Regulations. The sprinkler system shall be hydraulically calculated to meet the minimum density and pressure requirements per NFPA 13. The system installation shall include all necessary components, materials, accessories and equipment in order to complete a working, functional and code compliant system.
- B. The sprinkler system installation shall be fully coordinated with all other trades and disciplines. Sprinklers shall be located in accordance with NFPA 13 and manufacturer's requirements and recommendations. Sprinkler locations shall be coordinated with all architectural, mechanical, electrical and other building components and equipment.

- C. Sprinkler piping shall be sized to provide the specified density when the system is discharging over the total maximum discharge area as required by NFPA 13 for the protected hazard classification.
- D. The contractor shall be required to perform a water flow test as part of this contract that will establish the available water supply capacity for the sprinkler system. The water supply test shall establish the available flow and pressure at the point of connection to the building sprinkler system. The results of the contractor's hydrant flow test shall be utilized for all system design including final pump sizing. Obtain all permits, and notify the owner and owner's representative no fewer than 3 days prior to the scheduled date of testing.
- E. The sprinkler system shall be hydraulically calculated in accordance with NFPA 13.
- F. Hydraulic calculations for the wet standpipe system shall be conducted in accordance with NFPA 14.
- G. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.
- H. High-Pressure Piping System Component: Listed for 250-psig minimum working pressure.
- I. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- J. Sprinkler system and standpipe system design shall be approved by authorities having jurisdiction.
 - 1. Sprinkler Occupancy Hazard Classifications:
 - a. Refer to Contract Drawings
 - 2. Minimum Density for Automatic-Sprinkler Piping Design:
 - a. Refer to Contract Drawings and NFPA 13 requirements
 - 3. Maximum Protection Area per Sprinkler: Per UL listing and NFPA 13 requirements.
 - 4. Maximum Protection Area per Sprinkler:
 - a. Comply with NFPA 13

5. Total Combined Hose-Stream Demand Requirement: According to NFPA 13 and FM Global requirements unless otherwise indicated:
 - a. Light Hazard (HC-1) Occupancies: 250 gpm for 60 minutes
 - b. Ordinary Hazard Group I (HC-2) Occupancies: 250 gpm for 60 minutes
 - c. Ordinary Hazard Group II (HC-3) Occupancies: 500 gpm for 90 minutes
 - d. Extra-Hazard Occupancies: 500 gpm for 90 to 120 minutes
- K. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.
- L. The extent of the system work is mostly shown on the Contract Drawings and contained in the Specifications. Contract Drawings are diagrammatic and indicate general arrangement of systems and work included. The Specifications supplement the drawings and include items of work which are not detailed on the drawings. Submission of a proposal shall be evidence that the contractor has reviewed all of the Contract Documents and performed all necessary visits to determine the complete scope of work.
- M. The system shall be installed mostly as shown on the Contract Documents with design criteria as specified in this Section. This specification requires the Contractor to prepare and submit drawings, system schematics and any other documents needed for the procurement of approvals and the provision of a complete, functional and approved system. As a result, the Contract Drawings serve the purpose of indicating design criteria for the Contractor's use and guidance in preparing the required submittal documents for review.
- N. The contract drawings and specifications form complimentary requirements. Provide work specified and not shown, and work shown and not specified as though explicitly required by both. Although work is not specifically shown or specified, provide supplementary or miscellaneous items, appurtenances, devices and materials necessary for a sound, secure, complete and approved installation. Completely coordinate work of this specification with work of other trades and existing conditions.
- O. The Contractor is directed to bring to the attention of the Engineer, in writing, any discrepancies, deficiencies and/or other matters as they may relate to existing conditions, codes, standards, recommendations and/or job conditions. Failure of the Contractor to do so prior to bidding shall indicate acceptance of all documents herein and all job conditions.
- P. The Contractor shall bring to the attention of the Engineer any conflicts between these drawings and codes or standards for resolution.

- Q. Should the Contractor perform any work that does not comply with the requirements of the specifications, drawings and applicable codes, standards and references, the Contractor shall bear all costs arising in correcting the work to the satisfaction of the Engineer and owner.
- R. All materials, devices, and pipe joining methods shall be UL-listed and FM-approved

1.7 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 1. Partial submittals will not be acceptable and will be returned without review.
 - 2. Latest published manufacturer's data sheets; installation instructions; and inspection, testing, and maintenance document shall be provided in both hard copy and electronic copy.
 - 3. Data sheets shall include the specific make and model of the equipment being provided. Where more than one model is included on the documents, the contractor shall clearly indicate which model is being submitted. If the model is not clearly marked, the equipment submittal may be rejected.
- B. Shop Drawings: For wet-pipe sprinkler systems. Include plans, elevations, sections, details, and attachments to other work. Submit detailed shop drawings, in accordance with NFPA 13 "Working Plans." Information shall include but is not be limited to the following:
 - 1. Layout indicating details, plan view, elevations and sections of the system piping. Indicate the location of sprinklers and piping in relation to the ceiling layout, showing pipe lengths and sizes. Most recent reflected ceiling plans shall be utilized and provided on the shop drawings. Show locations of all sleeves used in fire protection systems.
 - 2. Detailed riser diagram showing a schematic of system supply, supply connection, devices, valves, pipe and fittings.
 - 3. Wiring Diagrams: For power, signal, and control wiring.
- A. Hydraulic calculations: Provide hydraulic calculations in accordance with NFPA 13, NFPA 14, and with the following:

1. Conduct hydraulic water flow test in accordance with "Performance Requirements" article.
 2. Hydraulic calculations shall be computer generated. The name of the hydraulic program shall be provided. Methods using Microsoft Excel or other spreadsheet type software programs will not be acceptable.
 3. Where the remote area is not evident, additional hydraulic calculations shall be submitted.
 4. Minimum operating pressure of any sprinkler shall be in accordance with NFPA 13, Listing and manufacturers installation instructions.
 5. Where multiple risers serve a floor plan and are looped, hydraulic calculations are required to consider the required flow from only one riser. Hydraulic calculations will not be accepted where flow is split through multiple risers.
 6. All hydraulic reference points shall be clearly identified and indicated on the shop drawings. An isometric and/or riser diagram shall be submitted to indicate all vertical connections between reference points.
 7. Margin of Safety for Available Water Flow and Pressure for Sprinkler System:
 - a. Non-Retail Spaces: Greater of 10% or 20 psi including losses through water-service piping, valves, and backflow preventers.
 8. Velocities in piping shall not exceed 15 feet per second or the maximum allowed by the manufacturer in sections that have paddle type flow switches. Velocity in piping shall be determined based on the flow demand of the system served by flow switch.
- B. Delegated-Design Submittal: For sprinkler 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.
- C. 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. Domestic water piping.
 2. Compressed air piping.
 3. HVAC hydronic piping.

- 4. Items penetrating finished ceiling include the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
- 5. Fire alarm system
- D. Qualification Data: For qualified Installer and professional engineer.
- E. Approved Sprinkler Piping and Standpipe Drawings: Working plans, prepared according to NFPA 13 and NFPA 14, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
- F. Welding certificates.
- G. Fire-hydrant flow test report within 1 year of submitted hydraulic calculations per Hydrant Flow Test Note #1, NFPA 14 10.2 and NFPA 13 22.1.3.
- H. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13 and NFPA 14. Include "Contractor's Material and Test Certificate for Aboveground Piping" and "Contractor's Material and Test Certificate for Underground Piping."
- I. Field quality-control reports.
- J. Operation and Maintenance Data: For sprinkler specialties to include in emergency, operation, and maintenance manuals.

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. 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. Shop drawings and hydraulic calculations shall be stamped by a qualified professional engineer.

- B. The Contractor shall furnish and install fire suppression system materials that are "Approved," "Identified" "Labeled," and "Listed" by a Nationally Recognized Testing Laboratory (NRTL) as suitable for the intended use. Any equipment and materials that are not NRTL "Approved," "Identified", "Labeled", and "Listed" that is installed by the contractor shall be removed and replaced at the contractor's expense.
- C. All equipment and components shall be new, and the manufacturer's current model. The materials, appliances, equipment and devices shall be tested and listed for use as part of a fire suppression system. The contractor shall be responsible for the satisfactory installation of the complete system.
- D. Each component of the fire suppression system shall be UL listed or FM approved. All components shall be installed in accordance with their specific listing and/or approval criteria. All equipment shall be installed in accordance with the manufacturer's recommendations and requirements.
- E. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
- 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. NFPA Standards: Sprinkler and fire suppression standpipe system equipment, specialties, accessories, installation, and testing shall comply with applicable NFPA standards.

1.9 COORDINATION

- A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.
- B. Coordinate fire suppression standpipes and hose connections with all required means of egress. All required widths for the means of egress shall be maintained and shall not be encroached upon by fire suppression standpipes or hose connections.

1.10 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.

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.
2. Special Tools: The Contractor shall supply the Owner with two complete sets of special tools and equipment necessary to perform routine maintenance on the sprinkler system.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.
- B. All materials and pipe joining methods shall be UL-listed and FM-approved.

2.2 STEEL PIPE AND FITTINGS

- A. Schedule 40, Black-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.
- B. Schedule 10, Black-Steel Pipe: ASTM A 135 or ASTM A 795/A 795M, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10, plain end.
- C. Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.
- D. Galvanized and Uncoated, Steel Couplings: ASTM A 865, threaded.
- E. Galvanized and Uncoated, 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.
- I. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.
- J. Grooved-Joint, Steel-Pipe Appurtenances:
 - 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. Anvil International, Inc.
 - b. Tyco Fire & Building Products LP.
 - c. Victaulic Company.
 - 2. Pressure Rating: 175 or 250 psig minimum as required.
 - 3. Galvanized and Uncoated, 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.
 - 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 bolts and nuts.

2.3 DUCTILE-IRON PIPE AND FITTINGS

- A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, minimum Class 52 with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
 - 1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern, rated for 350 psi working pressure.
 - 2. Gaskets: AWWA C111, styrene butadiene rubber (SBR) gaskets complying with Table 5-1 of AWWA M41.
 - 3. Bolts and nuts: Low carbon steel bolts conforming to ASTM A193, Grade B7.

4. Glands: Retainer glands shall be used for restraining the joint, and shall be MegaLug retainer glands as manufactured by EBBA Iron Inc. of Texas or approved qual.
- B. Locking Ring Type Restrained, Push-on-Joint, Ductile-Iron Pipe: AWWA C150 and AWWA C151, minimum Class 52 with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.
1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern, rated for 350 psi working pressure.
 2. Restraint: Positive “Locked-type” joints manufactured by the pipe and fitting manufacturer that utilize restraint independent of the joint gasket.
 3. Gaskets: AWWA C111, styrene butadiene rubber (SBR) gaskets complying with Table 5-1 of AWWA M41.
 4. Bolts and nuts: Low carbon steel conforming to ASTM A193, Grade B7.
 5. Glands: Retainer glands shall be used for restraining the joint, and shall be MegaLug retainer glands as manufactured by EBBA Iron Inc. of Texas or approved qual.
- C. Flanges: ASME 16.1, Class 125, cast iron.
- D. Cement Lining: Tar coat enamel double coated in accordance with AWWA C104 with a thickness not less than 1/8 inch on pipes 12 inches and smaller, and not less than 3/16 inches on pipe larger than 12 inches.
- E. Bituminous Coating: In accordance with AWWA C151.
- F. Manufacturer: Water pipe and restrained push-on-joints shall be as manufactured by one of the following manufacturers:
1. U.S. Pipe and Foundry (“TR Flex” joints)
 2. Griffin Pipe Products (“Snap Lok” joints)

3. Approved equal who is a member of the Ductile Iron Pipe Research Association (DIPRA)

2.4 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free.
 1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
 2. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.
- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- C. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
- 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.

2.5 LISTED FIRE-PROTECTION VALVES

- A. General Requirements:
 1. Valves shall be UL listed and FM approved.
 2. Minimum Pressure Rating for Standard-Pressure Piping: 175 psig.
 3. Minimum Pressure Rating for High-Pressure Piping: 250 psig
- B. Ball Valves:
 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. Anvil International, Inc.
 - b. Fivalco Inc.

- c. Victaulic Company.
 - d. Or approved equal
 - 2. Standard: UL 1091 except with ball instead of disc.
 - 3. Valves NPS 1-1/2 and Smaller: Bronze body with threaded ends.
 - 4. Valves NPS 2 and NPS 2-1/2: Bronze body with threaded ends or ductile-iron body with grooved ends.
 - 5. Valves NPS 3: Ductile-iron body with grooved ends.
- C. Check Valves:
- 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. Anvil International, Inc.
 - b. Milwaukee Valve Company.
 - c. Potter Roemer.
 - d. Reliable Automatic Sprinkler Co., Inc.
 - e. Tyco Fire & Building Products LP.
 - f. Victaulic Company.
 - g. Viking Corporation.
 - h. Or approved equal
 - 2. Standard: UL 312.
 - 3. Pressure Rating: 250 psig minimum.
 - 4. Type: Swing check.
 - 5. Body Material: Cast iron.
 - 6. End Connections: Flanged or grooved.
- D. Bronze OS&Y Gate Valves:

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. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Crane Co.; Crane Valve Group; Stockham Division.
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.
 - e. United Brass Works, Inc.
 - f. Or approved equal
 2. Standard: UL 262.
 3. Body Material: Bronze.
 4. End Connections: Threaded.
- E. Iron OS&Y Gate Valves:
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. Milwaukee Valve Company.
 - b. NIBCO INC.
 - c. Tyco Fire & Building Products LP.
 - d. United Brass Works, Inc.
 - e. Watts Water Technologies, Inc.
 - f. Or approved equal
 2. Standard: UL 262.
 3. Body Material: Cast or ductile iron.
 4. End Connections: Flanged or grooved.
- F. Indicating-Type Butterfly Valves:

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. Anvil International, Inc.
 - b. Kennedy Valve; a division of McWane, Inc.
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.
 - e. Tyco Fire & Building Products LP.
 - f. Victaulic Company.
 - g. Or approved equal
 2. Standard: UL 1091.
 3. Valves NPS 2 and Smaller:
 - a. Valve Type: Ball or butterfly.
 - b. Body Material: Bronze.
 - c. End Connections: Threaded.
 4. Valves NPS 2-1/2 and Larger:
 - a. Valve Type: Butterfly.
 - b. Body Material: Cast or ductile iron.
 - c. End Connections: Flanged, grooved, or wafer.
 5. Valve Operation: Integral electrical, prewired, single-circuit, supervisory switch visual indicating device.
- G. Indicating Type Butterfly valve – Supervised Closed
1. Butterfly valve designed to be Supervised Closed. Under normal operating conditions, the valve will remain closed.
 2. Valve Operation: Integral electrical, prewired, single-circuit, supervisory switch, visual indicating device.
- H. NRS Gate Valves:

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. American Valve, Inc.
 - b. Crane Co.; Crane Valve Group; Stockham Division.
 - c. Kennedy Valve; a division of McWane, Inc.
 - d. Mueller Co.; Water Products Division.
 - e. NIBCO INC.
 - f. Tyco Fire & Building Products LP.
 - g. Or approved equal
 2. Standard: UL 262.
 3. Body Material: Cast iron with indicator post flange.
 4. Stem: Nonrising.
 5. End Connections: Flanged or grooved.
- I. Indicator Posts:
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. American Valve, Inc.
 - b. Crane Co.; Crane Valve Group; Stockham Division.
 - c. Kennedy Valve; a division of McWane, Inc.
 - d. Mueller Co.; Water Products Division.
 - e. NIBCO INC.
 - f. Tyco Fire & Building Products LP.
 - g. Or approved equal
 2. Standard: UL 789.
 3. Type: Horizontal for wall mounting.

4. Body Material: Cast iron with extension rod and locking device.
5. Operation: Hand wheel.

2.6 TRIM AND DRAIN VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating: 175 or 250 psig minimum as required.

B. Angle Valves:

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. Fire Protection Products, Inc.
 - b. United Brass Works, Inc.
 - c. Or approved equal

C. Ball Valves:

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. Anvil International, Inc.
 - b. Kennedy Valve; a division of McWane, Inc.
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.
 - e. Potter Roemer.
 - f. Tyco Fire & Building Products LP.
 - g. Victaulic Company.
 - h. Watts Water Technologies, Inc.
 - i. Or approved equal

D. Globe Valves:

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. Fire Protection Products, Inc.
 - b. United Brass Works, Inc.
 - c. Victaulic Company.
 - d. Or approved equal

2.7 SPECIALTY VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating:
 - a. Standard-Pressure Piping Specialty Valves: 175 psig minimum.
 - b. High-Pressure Piping Specialty Valves: 250 psig
3. Body Material: Cast or ductile iron.
4. Size: Same as connected piping.
5. End Connections: Flanged or grooved.

B. Automatic (Ball Drip) Drain Valves:

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. AFAC Inc.
 - b. Reliable Automatic Sprinkler Co., Inc.
 - c. Tyco Fire & Building Products LP.
 - d. Or approved equal

2. Standard: UL 1726.
3. Type: Automatic draining, ball check.
4. Size: NPS 3/4
5. End Connections: Threaded.

2.8 BACKFLOW PREVENTERS

A. Double-Check, Backflow-Prevention Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
 - b. Conbraco Industries, Inc.; Apollo Valves.
 - c. FEBCO; SPX Valves & Controls.
 - d. Flomatic Corporation.
 - e. Watts Water Technologies, Inc.
 - f. Zurn Plumbing Products Group; Wilkins Water Control Products Division.
3. Standard: ASSE 1015.
4. Operation: Continuous-pressure applications unless otherwise indicated.
5. Pressure Loss: 5 psig (35 kPa) maximum, through middle one-third of flow range.
6. Size: As noted on plans
7. Pressure Loss at Design Flow Rate: 5 psi for NPS 2 (DN 50) and smaller; 5 psi for NPS 2-1/2 (DN 65) and larger.
8. Body Material: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 (DN 65) and larger.
9. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
10. Configuration: Designed for horizontal, straight through flow.
11. Accessories: Ball valves with threaded ends on inlet and outlet of NPS 2 (DN 50) and smaller; OS&Y gate valves with flanged ends on inlet and outlet of NPS 2-1/2 (DN 65) and larger.

2.9 HOSE CONNECTIONS WITHOUT PRESSURE REGULATING DEVICE

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. Elkhart Brass Mfg. Company, Inc.
 - b. Kennedy Valve; a division of McWane, Inc.
 - c. NIBCO INC.
 - d. Potter Roemer.
 - e. Tyco Fire & Building Products LP.
 - f. Or approved equal
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.
 9. Pressure Loss: Maximum 3.5 psi at 250 gpm
 10. Finish: Polished chrome plated.

2.10 FIRE-DEPARTMENT CONNECTIONS

A. Flush-Type, Fire-Department Connection, UL listed and FM approved:

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. AFAC Inc.
 - b. Croker
 - c. Elkhart Brass Mfg. Company, Inc.
 - d. Potter Roemer.

- e. Or approved equal
- 2. Standard: UL 405.
- 3. Type: Flush, for wall mounting.
- 4. Pressure Rating: 175 psig minimum.
- 5. Body Material: Corrosion-resistant metal.
- 6. 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.
- 7. Caps: Brass, lugged type, with gasket and chain.
- 8. Escutcheon Plate: Rectangular, brass, wall type.
- 9. Outlet: With pipe threads.
- 10. Body Style: square pattern.
- 11. Number of Inlets: Four
- 12. Escutcheon Plate Marking: Similar to "AUTO SPKR & STANDPIPE"
- 13. Finish: Polished chrome plated
- 14. Outlet Size: NPS 6.

2.11 FORWARD-FLOW TEST HEADER

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work included, but are not limited to, the following:
 - 1. AFAC Inc.
 - 2. Elkhart Brass Mfg Company, Inc.
 - 3. Croker

4. Potter Roemer.
 5. Or approved similar.
- B. Standard: Comply with requirements in NFPA 13.
- C. Header Pipe: ASTM A53/A53M, Schedule 40 galvanized steel, with ends threaded according to ASME B1.20.1.
- D. Header Pipe Fittings: ASME B16.4, galvanized cast-iron thread fittings.
- E. Automatic Drain Valve: UL 1726
- F. Manifold:
1. Test connections: Comply with UL 405; however, provide outlets without clappers instead of inlets.
 2. Body: Exposed type, brass, with number of outlets required by NFPA 13.
 3. Escutcheon Plate: Brass or bronze; round.
 4. Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads. Include caps and chains.
 5. Exposed Parts Finish: Brass, Chrome plated.
 6. Escutcheon Plate Marking: Equivalent to "TEST HEADER"
- 2.12 SPRINKLER SPECIALTY PIPE FITTINGS
- A. Branch Outlet Fittings:
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. Anvil International, Inc.
 - b. National Fittings, Inc.

- c. Tyco Fire & Building Products LP.
 - d. Victaulic Company.
 - e. Or approved equal
 - 2. Standard: UL 213.
 - 3. Pressure Rating: 175 or 250 psig minimum as required.
 - 4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
 - 5. Type: Mechanical-T and -cross fittings.
 - 6. Configurations: Solid back strap only, rolled steel strap types not permitted. Ductile-iron housing with branch outlets. Snap-on and strapless not permitted.
 - 7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
 - 8. Branch Outlets: Grooved, plain-end pipe, or threaded.
- B. Flow Detection and Test Assemblies:
- 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. AGF Manufacturing Inc.
 - b. Reliable Automatic Sprinkler Co., Inc.
 - c. Tyco Fire & Building Products LP.
 - d. Victaulic Company.
 - e. Or approved equal
 - 2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 - 3. Pressure Rating: 175 or 250 psig minimum as required
 - 4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.

5. Size: Same as connected piping.

6. Inlet and Outlet: Threaded.

C. Branch Line Testers:

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. Elkhart Brass Mfg. Company, Inc.
- b. Fire-End & Croker Corporation.
- c. Potter Roemer.
- d. Or approved equal

2. Standard: UL 199.

3. Pressure Rating: 175 or 250 psig minimum as required.

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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- a. AGF Manufacturing Inc.
- b. Tyco Fire & Building Products LP.
- c. Victaulic Company.
- d. Viking Corporation.
- e. Or approved equal

2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 or 250 psig minimum as required
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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CECA, LLC.
 - b. Corcoran Piping System Co.
 - c. Merit Manufacturing; a division of Anvil International, Inc.
 - d. Or approved equal
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.

2.13 SPRINKLERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide sprinklers manufactured by Reliable Automatic Sprinkler Co, Inc. If required products are not available from basis-of-design manufacturer, available manufacturers offering products that may be incorporated into the Work upon approval include, but are not limited to, the following:

1. Tyco Fire & Building Products LP.
 2. Victaulic Company.
 3. Viking Corporation.
 4. Or approved equal.
- B. General Requirements:
1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
 2. Pressure Rating for Automatic Sprinklers: 175 psig minimum.
 3. Pressure Rating for High-Pressure Automatic Sprinklers: 250 psig minimum.
- C. Automatic Sprinklers with Heat-Responsive Element:
1. Nonresidential Applications: UL 199
 2. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K as indicated in contract documents, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
- D. Sprinkler Finishes:
1. Chrome plated.
 2. Bronze.
 3. Painted.
 4. Non-ferrous
- E. 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, painted per architect, one piece, flat.
 2. Sidewall Mounting: chrome plated steel, painted per architect, one piece, flat.

F. Sprinkler Guards:

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. Reliable Automatic Sprinkler Co., Inc.
 - b. Tyco Fire & Building Products LP.
 - c. Victaulic Company.
 - d. Viking Corporation.
 - e. Or approved equal
2. Standard: UL 199, specifically listed with the sprinkler.
3. Type: Wire cage with fastening device for attaching to sprinkler.

2.14 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Water-Flow Indicators:

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. Potter Electric Signal Company.
 - b. System Sensor; a Honeywell company.
 - c. Viking Corporation.
 - d. Or approved equal
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.

C. Pressure Switches:

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. AFAC Inc.
 - b. Potter Electric Signal Company.
 - c. System Sensor; a Honeywell company.
 - d. Tyco Fire & Building Products LP.
 - e. Viking Corporation.
 - f. Or approved equal
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.

D. Valve Supervisory Switches:

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. Fire-Lite Alarms, Inc.; a Honeywell company.
 - b. Kennedy Valve; a division of McWane, Inc.
 - c. Potter Electric Signal Company.
 - d. System Sensor; a Honeywell company.
 - e. Or approved equal

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.

E. Indicator-Post Supervisory Switches:

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. Potter Electric Signal Company.
 - b. System Sensor; a Honeywell company.
 - c. Tyco Fire & Building Products LP.
 - d. Or approved equal
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.

2.15 PRESSURE GAGES

- 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. AMETEK; U.S. Gauge Division.
 2. Ashcroft, Inc.
 3. Brecco Corporation.

- 4. WIKA Instrument Corporation.
- 5. Or approved equal
- B. Standard: UL 393.
- C. Dial Size: 3-1/2- to 4-1/2-inch diameter.
- D. Pressure Gage Range: 0 to 250 psig minimum
- E. Water System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.
- F. Air System Piping Gage: Include retard feature and "AIR" or "AIR/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 EXAMINATION

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

3.3 SERVICE-ENTRANCE PIPING

- A. Connect sprinkler piping to water-service piping for service entrance to building. Comply with requirements for exterior piping in Section 21 11 00 "Facility Fire-Suppression Water-Service Piping."
- B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-service piping. Comply with

requirements for backflow preventers in Section 21 11 00 "Facility Fire-Suppression Water-Service Piping."

- C. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

3.4 PIPING INSTALLATION

- A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
 - 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.
- B. Piping Standard: Comply with requirements for installation of sprinkler and standpipe piping in NFPA 13 and NFPA 14.
- C. Install seismic restraints on piping. Comply with requirements for seismic-restraint device materials and installation in NFPA 13.
- 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. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.
- M. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.
- N. Pressurize and check dry sprinkler system piping and air-pressure maintenance devices and air compressors.
- O. Fill sprinkler system piping with water.
- P. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 21 05 17 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- Q. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 21 05 17 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- R. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 21 05 18 "Escutcheons for Fire-Suppression Piping."

3.5 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. Twist-Locked Joints: Insert plain end of steel pipe into plain-end-pipe fitting. Rotate retainer lugs one-quarter turn or tighten retainer pin.
- I. Steel-Piping, Pressure-Sealed Joints: Join lightwall steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.
- J. 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.
- K. Steel-Piping, Cut-Grooved Joints: Cut square-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 joints.
- L. 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.
- M. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.
- N. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.6 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. Install Butterfly Valves designed to be Supervised Closed as indicated on the drawings or for fire pump test headers, roof manifold valves or other valves intended to remain normally closed. These valves shall not be installed where water flow is required for normal system operation.
- E. Specialty Valves:
 - 1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
 - 2. Alarm Valves: Include bypass check valve and retarding chamber drain-line connection.

3.7 SPRINKLER INSTALLATION

- A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels. Refer to contract drawings for details
- B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.
- C. Sprinklers shall be furnished and installed to conform with manufacturer's listing.
- D. All sprinklers shall be coordinated with a final reflected ceiling plan and existing conditions to arrive at a suitable pattern consistent with proper sprinkler protection.
- E. Sprinklers shall be handled, installed, delivered and stored in accordance with manufacturer's requirements. Sprinklers shall not be subject to temperatures in excess of 100 °F. Glass bulb sprinklers shall have their bulb protectors removed at the time the system is placed in service for fire protection.

3.8 HOSE CONNECTION INSTALLATION

- A. Install hose connections adjacent to standpipes
- B. Install freestanding hose connections for access and minimum passage restriction.
- C. Install NPS 2-1/2 hose connections with quick-disconnect NPS 2-1/2 by NPS 1-1/2 reducer adapter.
- D. Coordinate hose connection installation with means of egress. Hose connections shall not impede the required means of egress.

3.9 FIRE-DEPARTMENT CONNECTION INSTALLATION

- A. Install wall-type, fire-department connections.
- B. Install automatic (ball drip) drain valve at each check valve for fire-department connection.

3.10 IDENTIFICATION

- A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13 and NFPA 14. Comply with requirements for identification specified in Section 21 05 53 - "Identification for Fire-Suppression Piping and Equipment."
- B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.11 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Leak Test: After installation, charge systems and test for leaks in accordance with NFPA 13 and NFPA 14. Repair leaks and retest until no leaks exist.
 - a. All sprinkler and standpipe piping and attached appurtenances subjected to system working pressure shall be hydrostatically tested at 200 psi and shall maintain that pressure without loss for 2 hours.

- b. Portions of systems normally subjected to system working pressures in excess of 150 psi based on the contractor's hydraulic calculations shall be tested at a pressure of 50 psi in excess of system working pressure.
 - c. Loss shall be determined by a reduction in gauge pressure or visual leakage. Gauge pressure shall be read at the low point of the system or portion being tested.
 - d. Piping between fire department connections and associated check valves shall be hydrostatically tested at 200 psi and shall maintain that pressure without loss for 2 hours.
 - 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. Flush, test and inspect standpipe systems according to NFPA 14, "System Acceptance" chapter.
 - 5. Energize circuits to electrical equipment and devices.
 - 6. Coordinate with fire-alarm tests. Operate as required.
 - 7. Coordinate with fire-pump tests. Operate as required.
 - 8. Verify that equipment hose threads are same as local fire-department equipment.
 - C. Sprinkler piping system and fire suppression standpipe system will be considered defective if it does not pass tests and inspections.
 - D. Prepare test and inspection reports. Complete "Contractor's Material and Test Certificate" and prepare a general information sign in accordance with NFPA 13.
- 3.12 CLEANING
- A. Clean dirt and debris from sprinklers.
 - B. Remove and replace sprinklers with paint other than factory finish.

3.13 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain specialty valves and pressure-maintenance pumps.

3.14 PIPING SCHEDULE

- A. Piping between Fire-Department Connections and Check Valves: Galvanized, schedule 40 steel pipe with grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
- B. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.
- C. Standard-pressure, wet-pipe sprinkler system, NPS 2 and smaller shall be the following:
 - 1. Schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
- D. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 and larger shall be the following:
 - 1. Schedule 10 or Schedule 40 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
- E. High-pressure, wet-pipe sprinkler system, NPS 2 and smaller shall be the following:
 - 1. Schedule 40, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
- F. High-pressure, wet-pipe sprinkler system, NPS 2-1/2 and larger, shall be the following:
 - 1. Schedule 40, black steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.15 SPRINKLER SCHEDULE

- A. Provide the following sprinkler types unless otherwise noted on the contract drawings:
 - 1. Rooms without Ceilings: Upright sprinklers
 - 2. Rooms with Suspended Ceilings: Concealed sprinklers.
 - 3. Wall Mounting: Sidewall sprinklers.
 - 4. Spaces Subject to Freezing: Upright or pendent dry sprinklers; and sidewall dry sprinklers as indicated
 - 5. Special Applications: Extended-coverage where indicated
 - 6. Provide quick response sprinklers in all light and ordinary hazard occupancies, and all other occupancies in which their use is listed or approved.
- B. Provide sprinkler types in subparagraphs below with finishes indicated.
 - 1. Concealed Sprinklers: Rough brass, with factory-painted cover plate. Refer to architectural drawings for required finishes.
 - 2. Upright, Pendent and Sidewall Sprinklers: Unless otherwise indicated in architectural drawings, black finish in finished spaces with exposed wood ceiling and 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 21 13 16

DRY-PIPE SPRINKLER SYSTEMS

(Part of Work of Section 21 00 01 – FIRE PROTECTION, Trade Bid Required)

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. Fire-protection valves.
- 3. Sprinkler specialty pipe fittings.
- 4. Sprinklers.
- 5. Alarm devices.
- 6. Control panels.
- 7. Pressure gages.

B. Related Sections:

- 1. Section 21 13 13 "Wet-Pipe Sprinkler Systems" for wet-pipe sprinkler piping.
- 2. Section 28 31 11 "Digital, Addressable Fire-Alarm System" for alarm devices not specified in this Section.

- C. The specifications and standards listed below form a part of this section of the specifications. The system shall fully comply with the latest issue, with all updates, of these standards as applicable. Where these standards conflict with other specified requirements, the most restrictive requirement shall govern.

1. Massachusetts State Codes and Regulations:

- a. 780 CMR Massachusetts State Building Code, 10th edition (MSBC) (International Building Code, 2023 Edition, as amended)
- b. 527 CMR Massachusetts Fire Prevention Regulations (MFPR) (NFPA 1, 2021 Edition, as amended)
- c. MGL 148 Massachusetts Fire Laws (MFL)
- d. 521 CMR Massachusetts Architectural Access Board (MAAB) Regulations
- e. NFPA 70, 2023 Edition, *National Electric Code* as amended by MFPR 12.00
- f. 2021 International Mechanical Code (IMC) as amended by MSBC 28
- g. 2021 International Energy Conservation Code & Stretch Energy Code

2. NFPA Standards

- a. NFPA 13, Standard for the Installation of Sprinkler Systems – 2019 edition
- b. NFPA 14, Standard for the Installation of Standpipe and Hose Systems – 2019 edition
- c. NFPA 20, Standard for the Installation of Stationary Pumps for Fire Protection – 2019 edition
- d. NFPA 24, Standard for the Installation of Private Service Mains and Their Appurtenances – 2019 edition
- e. NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water Based Fire Protection Systems, 2019 edition
- f. NFPA 72, National Fire Alarm and Signaling Code – 2019 edition

1.3 DEFINITIONS

- A. Standard-Pressure Sprinkler Piping: Dry-pipe sprinkler system piping designed to operate at working pressure 175 psig maximum.

1.4 SYSTEM DESCRIPTIONS

- A. Dry-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing compressed air. Opening of sprinklers releases compressed air and permits water pressure to open dry-pipe valve. Water then flows into piping and discharges from sprinklers that are open.

1.5 PERFORMANCE REQUIREMENTS

- A. The automatic sprinkler system shall be designed in accordance with all required and recommended provisions of NFPA 13, manufacturer requirements and Massachusetts State Regulations. The sprinkler system shall be hydraulically calculated to meet the minimum density and pressure requirements per NFPA 13. The system installation shall include all necessary components, materials, accessories and equipment in order to complete a working, functional and code compliant system.
- B. The sprinkler installation shall be fully coordinated with all other trades and disciplines. Sprinklers shall be located in accordance with NFPA 13 and manufacturer's requirements and recommendations. Sprinkler locations shall be coordinated with all architectural, mechanical, electrical and other building components and equipment.
- C. Sprinkler piping shall be sized to provide the specified density when the system is discharging over the total maximum discharge area as required by NFPA 13 for the protected hazard classification.
- D. The contractor shall be required to perform a water flow test as part of this contractor that will establish the available water supply capacity for the sprinkler system. The water supply test shall establish the available flow and pressure at the point of connection to the building sprinkler system. The results of the contractor's hydrant flow test shall be utilized for all system design including final pump sizing. Obtain all permits, and notify the owner and owner's representative no fewer than 3 days prior to the scheduled date of testing.
- E. The sprinkler system shall be hydraulically calculated in accordance with NFPA 13.
- F. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.
- G. High-Pressure Piping System Component: Listed for 250-psig minimum working pressure.

- H. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- I. Sprinkler system design shall be approved by authorities having jurisdiction.
 - 1. Sprinkler Occupancy Hazard Classifications:
 - a. Refer to Contract Drawings
 - 2. Minimum Density for Automatic-Sprinkler Piping Design:
 - a. Refer to Contract Drawings and NFPA 13 requirements
 - 3. Maximum Protection Area per Sprinkler:
 - a. Comply with NFPA 13, UL listing, and FM Global requirements
 - 4. Total Combined Hose-Stream Demand Requirement: According to NFPA 13 and FM Global requirements unless otherwise indicated:
 - a. Light Hazard Occupancies: 250 gpm for 60 minutes
 - b. Ordinary Hazard Group I Occupancies: 250 gpm for 60 minutes
 - c. Ordinary Hazard Group II Occupancies: 500 gpm for 90 minutes
 - d. Extra-Hazard Occupancies: 500 gpm for 90 to 120 minutes
- J. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.
- K. The extent of the system work is mostly shown on the Contract Drawings and contained in the Specifications. Contract Drawings are diagrammatic and indicate general arrangement of systems and work included. The Specifications supplement the drawings and include items of work which are not detailed on the drawings. Submission of a proposal shall be evidence that the contractor has reviewed all of the Contract Documents and performed all necessary visits to determine the complete scope of work.
- L. The system shall be installed mostly as shown on the Contract Documents with design criteria as specified in this Section. This specification requires the Contractor to prepare and submit drawings, system schematics and any other documents needed for the procurement of approvals and the provision of a complete, functional and approved system. As a result, the Contract Drawings serve the purpose of indicating design criteria for the Contractor's use and guidance in preparing the required submittal documents for review.

- M. The contract drawings and specifications form complimentary requirements. Provide work specified and not shown, and work shown and not specified as though explicitly required by both. Although work is not specifically shown or specified, provide supplementary or miscellaneous items, appurtenances, devices and materials necessary for a sound, secure, complete and approved installation. Completely coordinate work of this specification with work of other trades and existing conditions.
- N. The Contractor is directed to bring to the attention of the Engineer, in writing, any discrepancies, deficiencies and/or other matters as they may relate to existing conditions, codes, standards, recommendations and/or job conditions. Failure of the Contractor to do so prior to bidding shall indicate acceptance of all documents herein and all job conditions.
- O. The Contractor shall bring to the attention of the Engineer any conflicts between these drawings and codes or standards for resolution.
- P. Should the Contractor perform any work that does not comply with the requirements of the specifications, drawings and applicable codes, standards and references, the Contractor shall bear all costs arising in correcting the work to the satisfaction of the Engineer and owner.

1.6 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 1. Partial submittals will not be acceptable and will be returned without review.
 - 2. Latest published manufacturer's data sheets; installation instructions; and inspection, testing, and maintenance document shall be provided in both hard copy and electronic copy.
 - 3. Data sheets shall include the specific make and model of the equipment being provided. Where more than one model is included on the documents, the contractor shall clearly indicate which model is being submitted. If the model is not clearly marked, the equipment submittal may be rejected.
- B. Shop Drawings: For dry-pipe sprinkler systems. Include plans, elevations, sections, details, and attachments to other work. Submit detailed shop drawings, in accordance with NFPA 13 "Working Plans." Drawings shall be on uniform size

sheets. Coordination drawings will not be accepted in lieu of working plans. Information shall include but not be limited to the following:

1. Layout indicating details, plan view, elevations and sections of the system piping. Indicate the location of sprinklers and piping in relation to the ceiling layout, showing pipe lengths and sizes.
 2. Detailed riser diagram showing a schematic of system supply, supply connection, devices, valves, pipe and fittings.
 3. Wiring Diagrams: For power, signal, and control wiring.
- A. Hydraulic calculations: Provide hydraulic calculations in accordance with NFPA 13 and with the following:
1. Conduct hydraulic water flow test in accordance with "Performance Requirements" article.
 2. Hydraulic calculations shall be computer generated. The name of the hydraulic program shall be provided. Methods using Microsoft Excel or other spreadsheet type software programs will not be acceptable.
 3. Where the remote area is not evident, additional hydraulic calculations shall be submitted.
 4. Minimum operating pressure of any sprinkler shall be in accordance with NFPA 13 and appropriate listing.
 5. All hydraulic reference points shall be clearly identified and indicated on the shop drawings. An isometric and/or riser diagram shall also be submitted to clarify all vertical connections between reference points.
 6. Margin of Safety for Available Water Flow and Pressure for Sprinkler System: 10 percent but not less than 5 psi including losses through water-service piping, valves, and backflow preventers.
 7. Provide computer based calculation to estimate time delivered most remote sprinkler in accordance with NFPA 13.
 8. Velocities in piping shall not exceed 15 feet per second in sections that have paddle type flow switches.

- B. Delegated-Design Submittal: For sprinkler 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.
- C. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
- D. 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."

1.7 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. Domestic water piping.
 - 2. Compressed air piping.
 - 3. HVAC hydronic piping.
 - 4. Items penetrating finished ceiling including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - 5. Fire alarm system
- B. Qualification Data: For qualified Installer and professional engineer.
- C. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
- D. Fire-hydrant flow test report.
- E. 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."

- F. Field quality-control reports.

1.8 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sprinkler specialties to include in emergency, operation, and maintenance manuals.

1.9 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.
 - 2. Special Tools: The Contractor shall supply the Owner with two complete sets of special tools and equipment necessary to perform routine maintenance on the sprinkler systems.

1.10 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. 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. Shop drawings and hydraulic calculations shall be stamped by a qualified professional engineer.
- B. The Contractor shall furnish and install fire suppression system materials that are "Approved," "Identified," "Labeled," and "Listed" by a Nationally Recognized Testing Laboratory (NRTL) as suitable for the intended use. Any equipment and materials that are not NRTL "Approved," "Identified," "Labeled," and "Listed" that is installed by the contractor shall be removed and replaced at the contractor's expense.

- C. All equipment and components shall be new, and the manufacturer's current model. The materials, appliances, equipment and devices shall be tested and listed for use as part of a fire suppression system. The contractor shall be responsible for the satisfactory installation of the complete system.
- D. Each component of the fire suppression system shall be UL listed or FM approved. All components shall be installed in accordance with their specific listing and/or approval criteria. All equipment shall be installed in accordance with the manufacturer's recommendations and requirements.
- E. 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. NFPA Standards: Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the applicable NFPA standards.

1.11 COORDINATION

- A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 STEEL PIPE AND FITTINGS

- A. Schedule 40, Black-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.
- B. Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.
- C. uncoated, Steel Couplings: ASTM A 865, threaded.

D. Grooved-Joint, Steel-Pipe Appurtenances:

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. Anvil International, Inc.
 - b. Tyco Fire & Building Products LP.
 - c. Victaulic Company.
 - d. Or approved equal
2. Pressure Rating: 175 or 250 psig minimum as required.
3. Uncoated, 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.
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 bolts and nuts. All gaskets shall be flush seal, tri seal, or equivalent to prevent water from being trapped in the gaskets.

2.3 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free.
 1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
 2. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.
- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- C. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
- 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.

2.4 LISTED FIRE-PROTECTION VALVES

A. General Requirements:

1. Valves shall be UL listed or FM approved.
2. Minimum Pressure Rating: 175 or 250 psig minimum as required.

B. Ball Valves:

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. Anvil International, Inc.
 - b. Fivalco Inc.
 - c. Victaulic Company.
 - d. Or approved equal
2. Standard: UL 1091 except with ball instead of disc.
3. Valves NPS 1-1/2 and Smaller: Bronze body with threaded ends.
4. Valves NPS 2 and larger: Shall not be permitted.

C. Indicating-Type Butterfly Valves:

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. Anvil International, Inc.
 - b. Kennedy Valve; a division of McWane, Inc.
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.
 - e. Tyco Fire & Building Products LP.
 - f. Victaulic Company.
 - g. Or approved equal
2. Standard: UL 1091.

3. Valves NPS 2 and Smaller:
 - a. Valve Type: Ball or butterfly.
 - b. Body Material: Bronze.
 - c. End Connections: Threaded.
4. Valves NPS 2-1/2 and Larger:
 - a. Valve Type: Butterfly.
 - b. Body Material: Cast or ductile iron.
 - c. End Connections: Grooved.
5. Valve Operation: Integral electrical, single-circuit, supervisory switch visual indicating device.

2.5 TRIM AND DRAIN VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating: 250 psig minimum.

B. Angle Valves:

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. Fire Protection Products, Inc.
 - b. United Brass Works, Inc.
 - c. Or approved equal

C. Ball Valves:

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. Anvil International, Inc.

- b. Kennedy Valve; a division of McWane, Inc.
- c. Milwaukee Valve Company.
- d. NIBCO INC.
- e. Potter Roemer.
- f. Watts Water Technologies, Inc.
- g. Or approved equal

D. Globe Valves:

- 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. Fire Protection Products, Inc.
 - b. United Brass Works, Inc.
 - c. Or approved equal

2.6 SPECIALTY VALVES

A. General Requirements:

- 1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
- 2. Pressure Rating: 175 or 250 psig minimum as required.
- 3. Body Material: Cast or ductile iron.
- 4. Size: Same as connected piping.
- 5. End Connections: Flanged or grooved.

A. Dry-Pipe Valves:

- 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. Reliable Automatic Sprinkler Co., Inc.

- b. Tyco Fire & Building Products LP.
 - c. Victaulic Company.
 - d. Viking Corporation.
 - e. Or approved equal
 - 2. Standard: UL 260
 - 3. Design: Differential-pressure type.
 - 4. Include UL 1486, quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
 - 5. Factory assembled with trim configuration shall be acceptable.
 - 6. Air-Pressure Maintenance Device:
 - 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) Reliable Automatic Sprinkler Co., Inc.
 - 2) Tyco Fire & Building Products LP.
 - 3) Victaulic Company.
 - 4) Viking Corporation.
 - 5) Or approved equal
 - b. Standard: UL 260.
 - c. Type: Automatic device to maintain minimum air pressure in piping.
 - d. Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure, strainer, pressure ratings with 14- to 60-psig adjustable range, and 175-psig outlet pressure.
- B. Automatic (Ball Drip) Drain Valves:
- 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. Reliable Automatic Sprinkler Co., Inc.

- b. Tyco Fire & Building Products LP.
 - c. Or approved equal
- 2. Standard: UL 1726.
- 3. Pressure Rating: 175 or 250 psig minimum as required.
- 4. Type: Automatic draining, ball check.
- 5. Size: NPS 3/4.
- 6. End Connections: Threaded.

2.7 SPRINKLER SPECIALTY PIPE FITTINGS

- A. General Requirements for Dry-Pipe-System Fittings: UL listed for dry-pipe service.

- A. Branch Outlet Fittings:

- 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. Anvil International, Inc.
 - b. National Fittings, Inc.
 - c. Shurjoint Piping Products.
 - d. Victaulic Company.
 - e. Or approved equal
 - 2. Standard: UL 213.
 - 3. Pressure Rating: 175 or 250 psig minimum as required.
 - 4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
 - 5. Type: –Welded outlet fittings.
 - 6. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
 - 7. Branch Outlets: Grooved, plain-end pipe, or threaded.

DRY PIPE SPRINKLER SYSTEMS

B. Flow Detection and Test Assemblies:

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. AGF Manufacturing Inc.
 - b. Reliable Automatic Sprinkler Co., Inc.
 - c. Tyco Fire & Building Products LP.
 - d. Victaulic Company.
 - e. Or approved equal
2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 or 250 psig minimum as required
4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

C. Sprinkler Inspector's Test Fittings:

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. AGF Manufacturing Inc.
 - b. Tyco Fire & Building Products LP.
 - c. Victaulic Company.
 - d. Viking Corporation.
 - e. Or approved equal
2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 or 250 psig minimum as required

4. Body Material: Cast- or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

D. Adjustable Drop Nipples:

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. CECA, LLC.
 - b. Corcoran Piping System Co.
 - c. Merit Manufacturing; a division of Anvil International, Inc.
 - d. Or approved equal
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.

2.8 SPRINKLERS

- 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. Reliable Automatic Sprinkler Co., Inc.
 2. Tyco Fire & Building Products LP.
 3. Victaulic Company.
 4. Viking Corporation.

5. Or approved equal

B. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
2. Pressure Rating for Automatic Sprinklers: 175 psig minimum.

C. Automatic Sprinklers with Heat-Responsive Element:

1. Nonresidential Applications: UL 199.
2. 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.

D. Sprinkler Finishes:

1. Chrome plated.
2. Bronze.
3. Factory finished black

E. 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: one piece, flat, finish per architect.
2. Sidewall Mounting: steel white finish, one piece, flat.

F. Sprinkler Guards:

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. Reliable Automatic Sprinkler Co., Inc.
 - b. Tyco Fire & Building Products LP.
 - c. Victaulic Company.
 - d. Viking Corporation.

- e. Or approved equal
- 2. Standard: UL 199, specifically listed with the sprinkler.
- 3. Type: Wire cage with fastening device for attaching to sprinkler.

2.9 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Pressure Switches:

- 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. AFAC Inc.
 - b. Potter Electric Signal Company.
 - c. System Sensor; a Honeywell company.
 - d. Tyco Fire & Building Products LP.
 - e. Viking Corporation.
 - f. Or approved equal
- 2. Standard: UL 346.
- 3. Type: Electrically supervised water-flow switch.
- 4. Components: Single-pole, double-throw switch with normally closed contacts.
- 5. Design Operation: Rising pressure signals water flow.

C. Valve Supervisory Switches

- 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. Fire-Lite Alarms; a Honeywell company.
 - b. Kennedy Valve; a division of McWane, Inc.

- c. Potter Electric Signal Company.
 - d. System Sensor; a Honeywell company.
 - e. Or approved equal
- 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.

2.10 PRESSURE GAGES

- 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. AMETEK, Inc.; U.S. Gauge Division.
 - 2. Ashcroft, Inc.
 - 3. Brecco Corporation.
 - 4. WIKA Instrument Corporation.
 - 5. Or approved equal
- B. Standard: UL 393.
- C. Dial Size: 3-1/2- to 4-1/2-inch diameter.
- D. Pressure Gage Range: 0 to 250 psig minimum.
- E. Water System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.
- F. Air System Piping Gage: Include "AIR" or "AIR/WATER" label on dial face.

2.11 NITROGEN GENERATION SYSTEM

- A. Manufacturers: The basis of design manufacturer is Engineered Corrosion Solutions. Subject to compliance with project requirements, other equivalent manufacturers and products may be submitted for consideration including the following:
1. Tyco Fire & Building Products LP.
 2. Potter Roemer
 3. Or approved equal
- B. Nitrogen Generator.
1. Furnish and install a nitrogen generator system at each fire sprinkler riser room to service all dry zones as required by the system size and pressure requirement stipulated in the drawings and installed per manufacturer's instructions.
 2. The nitrogen generator shall have an air compressor that is sized appropriately for the application and capable of achieving system supervisory pressure within 30 minutes in accordance with requirements of NFPA 13.
 3. The nitrogen generator shall provide a minimum of 98% purity nitrogen to the fire sprinkler system.
 4. The nitrogen generator shall be equipped with a filtration system to remove residual water and all hydrocarbons from the air stream.
 5. The nitrogen generator shall have a nitrogen control panel capable of monitoring compressor runtimes, nitrogen generator pressure, and operational mode locally and over the internet.
 6. The nitrogen generator shall have a leak detection system capable of determining sprinkler system leak rates and give alerts if leaks develop within the sprinkler piping, nitrogen generator system or air compressor.
 7. Alerts shall be capable of being e-mailed.
 8. The nitrogen generator systems shall have the ability to automatically switch between air bypass mode and nitrogen generating mode based on the demands of the sprinkler system.

9. The nitrogen generator shall have an air storage tank and nitrogen storage tank air that confirm to ASME standard for pressure vessel.
10. The nitrogen generator is FM approved.

C. Purge Valve

1. Furnish and install a nitrogen purge valve per manufacturer requirements.
2. The nitrogen purge valve shall be supplied with a restricted orifice which size is determined by the total system pressure requirements.
3. The nitrogen purge valve shall shut off the purge valve after 98% nitrogen has been achieved throughout the fire sprinkler system.
4. The nitrogen purge valve shall be closed during hydrostatic testing and air pressure testing of the fire sprinkler system and then placed in the open position for the commissioning, treatment and operation of the system.

D. Air Maintenance Device

1. Furnish and install an Air Maintenance Device for each dry fire sprinkler system.
2. Air Maintenance Device shall be equipped with an adjustable pressure regulator that is capable of setting the required pressure for the fire sprinkler system.
3. The Air Maintenance Device shall be listed or approved for fire sprinkler applications.
4. The Air Maintenance Device shall be installed per manufacturer's specifications.
5. The Air Maintenance device shall be installed no greater than 7-ft above the finished floor and shall be readily accessible.

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 PIPING INSTALLATION

- A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
 - 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.
- B. Piping Standard: Comply with requirements in NFPA 13 for installation of sprinkler piping.
- C. Install seismic restraints on piping. Comply with requirements in NFPA 13 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 valves to drain piping between fire-department connections and check valves. Drain to floor drain or to outside building.
- K. Connect nitrogen generator to the following piping and wiring:
 - 1. Pressure gages and controls.
 - 2. Electrical power system.
 - 3. Fire-alarm devices, including low-pressure alarm.
- L. Install alarm devices in piping systems.
- M. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements in NFPA 13 for hanger materials.
- N. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.
- O. Drain dry-pipe sprinkler piping.
- P. Pressurize and check dry-pipe sprinkler system piping and air-pressure maintenance devices and air compressors.
- Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 21 05 17 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 21 05 17 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 21 05 18 "Escutcheons for Fire-Suppression Piping."

3.3 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. Twist-Locked Joints: Insert plain end of steel pipe into plain-end-pipe fitting. Rotate retainer lugs one-quarter turn or tighten retainer pin.
- I. Steel-Piping, Cut-Grooved Joints: Cut square-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 joints.
- J. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Braze Joints" Chapter.
- K. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2104. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

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

3.4 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. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
 - 2. Dry-Pipe: Install trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
 - a. Install nitrogen generator and compressed-air supply piping.
 - b. Air-Pressure Maintenance Device: Install shutoff valves to permit servicing without shutting down sprinkler system; bypass valve for quick system filling; pressure regulator or switch to maintain system pressure; strainer; pressure ratings with 14- to 60-psig adjustable range; and 175-psig maximum inlet pressure. Air pressure maintenance devices shall be installed as recommended by the manufacturer for all dry pipe systems.
 - c. Install compressed-air supply piping from building's compressed-air piping system.

3.5 SPRINKLER INSTALLATION

- A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels.

- B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.
- C. Sprinklers shall be furnished and installed to conform with manufacturer's listing.
- D. All sprinklers shall be coordinated with a final reflected ceiling plan to arrive at a suitable pattern consistent with proper sprinkler protection.
- E. Where used, install sprinklers into flexible, sprinkler hose fittings and install hose into bracket on ceiling grid.
- F. Sprinklers shall be handled, installed, delivered and stored in accordance with manufacturer's requirements. Sprinklers shall not be subject to temperatures in excess of 100 °F. Glass bulb sprinklers shall have their bulb protectors removed at the time the system is placed in service for fire protection.

3.6 IDENTIFICATION

- A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13. Comply with requirements for identification specified in Section 21 05 53 – "Identification for Fire-Suppression Piping and Equipment."
- B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
 - a. All sprinkler and standpipe piping and attached appurtenances subjected to system working pressure shall be hydrostatically tested at 200 psi and shall maintain that pressure without loss for 2 hours.
 - b. Portions of systems normally subjected to system working pressures in excess of 150 psi based on the contractor's hydraulic calculations shall be tested at a pressure of 50 psi in excess of system working pressure.

- c. Loss shall be determined by a reduction in gauge pressure or visual leakage. Gauge pressure shall be read at the low point of the system or portion being tested.
 - 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. Start and run air compressors.
 - 6. Coordinate with fire-alarm tests. Operate as required.
 - 7. Coordinate with fire-pump tests. Operate as required.
 - 8. Verify that equipment hose threads are same as local fire-department equipment.
 - C. Sprinkler piping system will be considered defective if it does not pass tests and inspections.
 - D. Prepare test and inspection reports.
- 3.8 CLEANING
- A. Clean dirt and debris from sprinklers.
 - B. Remove and replace sprinklers with paint other than factory finish.
- 3.9 DEMONSTRATION
- A. Train Owner's maintenance personnel to adjust, operate, and maintain specialty valves.

3.10 PIPING SCHEDULE

- A. Piping between Fire-Department Connections and Check Valves: Galvanized, standard-weight steel pipe with grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
- B. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.
- A. Dry-pipe sprinkler system, NPS 1-1/2 and smaller, shall be one of the following:
 - 1. At exterior of building:
 - a. Schedule 40, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - 2. At interior of building (with nitrogen filling):
 - a. Schedule 40, black-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
- B. Dry-pipe sprinkler system, NPS 2-1/2 and larger, shall be one of the following:
 - 1. At exterior of building:
 - a. Schedule 40, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - b. Schedule 40, galvanized-steel pipe with roll-grooved ends; galvanized, grooved-end fittings for steel piping; galvanized grooved-end-pipe couplings for steel piping; and grooved joints. Grooved couplings shall use flush seal gaskets.
 - 2. At interior of building (with nitrogen filling):
 - a. Schedule 40, black-steel pipe with threaded ends; gray-iron threaded fittings; and threaded joints.
 - b. Schedule 40, black-steel pipe with roll-grooved ends; grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints. Grooved couplings shall use flush seal gaskets.

3.11 SPRINKLER SCHEDULE

- A. Use sprinkler types in subparagraphs below for the following applications:

DRY PIPE SPRINKLER SYSTEMS

1. Rooms without Ceilings: Upright sprinklers.
 2. Rooms with Suspended Ceilings: Dry pendent, recessed, and flush sprinklers as indicated.
 3. Wall Mounting: Dry sidewall sprinklers.
 4. Special Applications: Extended-coverage and quick-response sprinklers where indicated.
- B. Provide sprinkler types in subparagraphs below with finishes indicated.
1. Concealed Sprinklers: Rough brass, with factory-painted cover plate per architect.
 2. Upright, Pendent, and Sidewall Sprinklers: Painted in finished spaces exposed to view per architect; rough bronze in unfinished spaces not exposed to view.

END OF SECTION

SECTION 22 00 01

PLUMBING

(Trade Bid Required)

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 the Specifications.
- B. Time, Manner and Requirements for Submitting Trade Bids:
 - 1. Trade bids for work under this Section shall be for the complete work and shall be filed in a sealed envelope with the Owner at a time and place as stipulated in the "INSTRUCTIONS TO BIDDERS".
 - a. The following should appear on the upper left hand corner of the envelope:
 - b. NAME OF TRADE BIDDER: (Insert name of trade bidder)
 - c. TRADE BID FOR SECTION: 22 00 01 - PLUMBING
 - d. Each trade bid submitted for work under this Section shall be on forms furnished by the Owner as required by Section 8 of Chapter 149A of the General Laws, as amended. Trade bid forms may be obtained at the office of the Owner.
 - 2. Trade bids filed with the Owner shall be accompanied by BID BOND or CASH or CERTIFIED CHECK or TREASURER'S CHECK or CASHIER'S CHECK issued by a responsible bank or trust company payable to the City of Worcester in the amount of five percent of the trade bid. A trade bid accompanied by any other form of bid deposit than those specified will be rejected.
- C. Trade Sub-Bid Requirements: (None required under this Section.)
- D. Reference Drawings: The Work of this Trade Bid is shown on the following Contract Drawings:
 - 1. 01-GENERAL Series
 - 2. 22-PLUMBING Series

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. All Work of the following sections:
 - a. 22-PLUMBING Series
 2. Firestopping for the Work of this Section, including cutting penetrations and firestopping; complying with requirements specified in Section 07 84 13 - PENETRATION FIRESTOPPING.
 3. Core drilling for the Work of this Section.
 4. Certified seismic restraints to meet the Commonwealth of Massachusetts Building Code applicable at the time the building permit is issued.
 5. Coordination drawings and record drawings and similar requirements.
 6. CAMIS excel spreadsheet data collection for Equipment Template and PM Procedure tabs as described in Section 01 77 00 - CLOSEOUT PROCEDURES
 7. BIM modeling as specified in this Section and in Section 01 31 29 - COORDINATION DRAWINGS.
- B. Alternates: Not Applicable.
- C. Items To Be Installed Only: Install the following items as furnished by the designated Sections:
1. Section 10 28 13 - TOILET ACCESSORIES:
 - a. Toilet room accessories.
- D. Items To Be Furnished Only: Furnish the following items for installation by the designated Sections:
1. Section 04 20 00 – UNIT MASONRY
 - a. Access doors in masonry openings.
 2. Section 07 54 23 – THERMOPLASTIC-POLYOLEFIN (TPO) ROOFING:
 - a. Roof drain sump receivers.
 3. Section 09 29 00 - GYPSUM BOARD ASSEMBLIES:
 - a. Access doors in gypsum board assemblies.
 4. Section 09 30 13 - TILING:
 - a. Access doors in tile.
 5. Section 09 51 13 - ACOUSTICAL PANEL CEILINGS:
 - a. Access doors in acoustical panel ceilings.
 6. Section 26 00 01 - ELECTRICAL WORK:
 - a. Magnetic starters.
- E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
1. Section 03 30 00 - CAST-IN-PLACE CONCRETE for cutting and patching of concrete walls.
 2. Section 06 10 00 - ROUGH CARPENTRY for blocking for toilet accessories.
 3. Section 07 54 23 – THERMOPLASTIC-POLYOLEFIN (TPO) ROOFING for flashing of roof mounted equipment and roofing penetrations.
 4. Section 07 62 00 – SHEET METAL FLASHING AND TRIM for flashing of roof mounted equipment and roofing penetrations.
 5. Section 07 84 13 – PENETRATION FIRESTOPPING for coordination of floor and wall penetrations with firestopping contractor.

6. Section 09 29 00 – GYPSUM BOARD ASSEMBLIES for coordination with gypsum ceilings and blocking for toilet accessories.
 7. Section 09 51 13 – ACOUSTICAL PANEL CEILINGS for coordination with acoustical ceilings.
 8. Section 23 00 01 – HEATING, VENTILATING AND AIR CONDITIONING for coordination with HVAC piping and ductwork and for condensate drains.
 9. Section 26 00 01 - ELECTRICAL WORK for fire alarm devices and wiring.
 10. Section 31 00 00 – EARTH MOVING for excavation and backfilling.
- F. Perform work and provide material and equipment as shown on Drawings and as specified or indicated in this Section of the Specifications. Completely coordinate work of this Section with work of other trades and provide a complete and fully functional installation.
- G. Drawings and Specifications form complimentary requirements; provide work specified and not shown, and work shown and not specified as though explicitly required by both. Although work is not specifically shown or specified, provide supplementary or miscellaneous items, appurtenances, devices and materials obviously necessary for a sound, secure and complete installation.
- H. Give notices, file plans, obtain permits and licenses, pay fees and back charges, and obtain necessary approvals from authorities that have jurisdiction as required to perform work in accordance with all legal requirements and with Specifications, Drawings, Addenda and Change Orders, all of which are part of Contract Documents.

END OF SECTION

SECTION 22 05 00

COMMON WORK RESULTS FOR PLUMBING

(Part of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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.
- B. Conform to the requirements specified under Section 23 05 00 - Basic HVAC Requirements.
- C. Conform to all electrical requirements under Section 26 05 00 - Common Work Results for Electrical.
- D. Conform to all applicable rules and regulations of local and state agencies including:
 - 1. Massachusetts State Plumbing Code – 248CMR
 - 2. Massachusetts Building Code 10th Edition – 780CMR
 - 3. AHJ Fire Marshal Requirements
 - 4. Americans with Disabilities Act (ADA)
 - 5. ANSI – American National Standards Institute
 - 6. UL – Underwriters Laboratories
 - 7. AGA – American Gas Association
 - 8. ASME – American Society of Mechanical Engineers
 - 9. ASSE – American Society of Sanitary Engineers
 - 10. ASTM – American Society for Testing and Materials
 - 11. AWWA – American Water Works Association
 - 12. NSF – National Sanitation Foundation
 - 13. PDI – Plumbing and Drainage Institute

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. Dielectric fittings.
 - 3. Mechanical sleeve seals.
 - 4. Sleeves.
 - 5. Unions and flanges.
 - 6. Mechanical grooved pipe connection.
 - 7. Escutcheons.
 - 8. Equipment installation requirements common to equipment sections.
 - 9. Concrete bases.
 - 10. Supports and anchorages.
- B. Pipe tube and fittings furnished as part of fabricated equipment are specified as part of equipment assembly in other sections.

1.3 REFERENCES

- A. Abbreviations of standards organizations referenced in this and other sections are as follows:
 - 1. ANSI B16.3 Malleable Iron Threaded Fittings.
 - 2. ANSI B16.4 Cast Iron Threaded Fittings.
 - 3. ANSI B16.5 Pipe Flanges and Flanged Fittings.
 - 4. ANSI B16.22 Wrought Copper and Wrought Copper Alloy Solder Joint Pressure Fittings.
 - 5. ANSI B16.29 Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings – DWV.
 - 6. ASTM A53 Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless.
 - 7. ASTM A74 Cast Iron Soil Pipe and Fittings.
 - 8. ASTM A105 Forgings, Carbon Steel, for Piping Components.
 - 9. ASTM A126 Gray Cast Iron Castings for Valves, Flanges, and Pipe Fittings.

10. ASTM A234 Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures.
11. ASTM A861 High Silicon Iron Pipe and Fittings.
12. ASTM B32 Solder Metal.
13. ASTM B88 Seamless Copper Water Tube.
14. ASTM B306 Copper Drainage Tube (DWV).
15. ASTM B813 Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube.
16. ASTM C564 Rubber Gaskets for Cast Iron Soil Pipe and Fittings
17. AWS A5.8 Brazing Filler Metal.
18. AWWA C104 Cement Mortar Lining for Ductile Iron Pipe and Fittings for Water.
19. AWWA C110 Ductile Iron and Gray Iron Fittings, 3 In. Through 48 In., for Water and Other Liquids.
20. AWWA C111 Rubber Gasket Joints for Ductile Iron and Gray Iron Pressure Pipe and Fittings.
21. AWWA C151 Ductile Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds for Water or Other Liquids.
22. AWWA C153 Ductile Iron Compact Fittings, 3 In. Through 48 In., for Water and Other Liquids.
23. AWWA C600 Installation of Ductile Iron Water Mains and Their Appurtenances.
24. AWWA C651 Disinfecting Water Mains.
25. CISPI 301 Hubless Cast Iron Soil Pipe And Fittings For Sanitary And Storm Drain, Waste, And Vent Piping Applications.
26. CISPI 310 Couplings For Use In Connection With Hubless Cast Iron Soil Pipe And Fittings For Sanitary And Storm Drain, Waste And Vent Piping Applications.

1.4 QUALITY ASSURANCE

- A. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

- B. Order all copper, cast iron, steel, plastic pipe with each length marked with the name or trademark of the manufacturer and type of pipe; with each shipping unit marked with the purchase order number, metal or alloy designation, temper, size and name of supplier.
- C. Manufacturers: Firms regularly engaged in manufacture of pipe, tube and fittings of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
- D. Welding procedures, welders, and welding operators for all building service piping to be in accordance with certified welding procedures of the National Certified Pipe Welding Bureau and Section 927.5 of ASME B31.9 Building Services Piping or AWS 10.9 Qualification of Welding Procedures and Welders for Piping and Tubing. Before any metallic welding is performed, Contractor to submit his Standard Welding Procedure Specification together with the Procedure Qualification Record as required by Section 927.6 of ASME B31.9 Building Services Piping.
- E. Before any polyethylene fusion welding is performed, the Contractor shall submit certification that the welders to be used on this project have successfully demonstrated proper welding procedures in accordance with the Code of Federal Regulations, Title 49, Part 192, and Section 192.285.
- F. The Owner reserves the right to test the work of any welder employed on the project, at the Contractor's expense. If the work of the welder is found to be unsatisfactory, the Contractor shall be prevented from doing further welding on the project and all defective welds replaced.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Promptly inspect shipments to ensure that the material is undamaged and complies with specifications.
- B. Cover pipe to prevent corrosion or deterioration while allowing sufficient ventilation to avoid condensation. Do not store materials directly on grade. Protect pipe, tube, and fitting ends so they are not damaged. Except for hub-and-spigot, and similar units of pipe, provide end caps on each length of pipe and tube and take precautions so the caps remain in place. Protect fittings, flanges, and unions by storage inside or by durable, waterproof, above ground packaging.
- C. Offsite storage agreements will not relieve the contractor from using proper storage techniques.
- D. Storage and protection methods must allow inspection to verify products.

1.6 DESIGN CRITERIA

- A. Use only new material, free of defects, rust and scale, and meeting the latest revision of ASTM, AWWA or CISPI specifications as listed in this specification.
- B. Construct all piping for the highest pressures and temperatures in the respective system.
- C. Where weld fittings or mechanical grooved fittings are used, use only long radius elbows having a centerline radius of 1.5 pipe diameters.

1.7 SYSTEM PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing piping systems with following minimum working pressure ratings, except where otherwise indicated:
 - 1. Water Distribution Systems, below ground: 250 psig.
 - 2. Water Distribution Systems, above ground: 250 psig.
 - 3. Soil, Waste, and Vent Systems: 10-foot head of water.
 - 4. Storm Drainage Systems: 10-foot head of water.

1.8 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.
- B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- C. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section - Access Doors and Frames.

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 22 Piping Sections for pipe, tube, and fitting materials and joining methods.

2.2 JOINING MATERIALS

- A. Refer to individual Division 22 Piping Sections for special joining materials not listed below.

2.3 TRANSITION FITTINGS

- A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
 - 1. Underground Piping NPS 1-1/2 and smaller: Manufactured fitting or coupling.
 - 2. Underground Piping NPS 2 and larger: AWWA C219, metal sleeve-type coupling.
 - 3. Aboveground Pressure Piping: Pipe fitting.
- B. Plastic-to-Metal Transition Fittings: PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
- C. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
- D. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC, PVC, CPVC and PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.
- E. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve; ends same size as piping to be joined, and corrosion-resistant metal band on each end.

2.4 UNIONS AND FLANGES

- A. General: Unions, flanges and gasket materials to have a pressure rating of not less than 150 psig at 180 degrees.
- B. 2-1/2 inches and smaller steel: ASTM A197/ANSI B16.3 malleable iron unions with brass seats. Use black malleable iron on black steel piping and galvanized malleable iron on galvanized steel piping.
- C. 2-1/2 inches and smaller copper: ANSI B16.18 cast bronze union coupling or ANSI B15.24 Class 150 cast bronze flanges.
- D. 3 inches and larger steel: ASTM A181 or A105, grade 1 hot forged steel flanges of threaded, welding neck, or slip-on pattern on black steel and threaded only on galvanized steel. Use raised face flanges ANSI B16.5 for mating with other raised face flanges or equipment with flat ring or full-face gaskets. Use ANSI B16.1 flat face flanges with full-face gaskets for mating with other flat face flanges on equipment.
- E. 3 inches and larger copper: ANSI B15.24 Class 150 cast bronze flanges with full-face gaskets.

2.5 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 degrees F.
- D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
- E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - 1. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.
- F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 degrees F.
- G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 degrees F.
- H. All Services
 - 1. 2-1/2 inches and smaller: Screwed, Schedule 40 electro zinc plated ASTM A120/A53 casing with inert self-cleaning thermoplastic liner, 300 psi VP at 225 degrees F. Victaulic Clearflow Style 47 or equal (no known equal).
 - 2. 3 inches and larger: Flanged with isolation gaskets, washers and sleeves, 300 lbs. WOG. Maloney or equal (no known equal).

2.6 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - 1. Sealing Elements: EPDM 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. Include two for each sealing element.

3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES AND OPENINGS

- A. Provide sleeves for piping passing through concrete walls, floors and roofs.
- B. Set pipe sleeves and inserts in place before concrete is poured. Coordinate the placing of these items to avoid delaying concrete placing operations.
- C. Locate chases, shafts and openings required for the installation of the mechanical work during framing of the structure. Do any additional cutting and boring required due to improperly located or omitted openings without cost to the Owner under the supervision of the Owner's Representative.
- D. Size sleeves for below grade pipe a minimum of 2 inches beyond outside of pipe. Size above grade pipe sleeves in accordance with Fire Marshal requirements and UL Building Materials / Fire Resistive Directory.
- E. Coat surface of all sleeves in contact with concrete, masonry or soil with two coats of coal tar bitumastic paint.
- F. Provide sleeves as follows:

Location	Material
Nonmembrane Floor, Construction	Non-adjustable galvanized sheet metal with deck flange and end cap. 2 inches and smaller 22 gauge, 3 inches -20 gauge, 4 inches and larger - 16 gauge.
Exterior Walls below Grade	Standard weight galvanized steel pipe with a continuously welded water stop of 1/4 inch steel plate extending from outside of sleeve a minimum of 2 inches all around. Provide modular mechanical-type seal consisting of interlocking synthetic rubber links with bolts shaped to continuously fill the annular space between the pipe and sleeve. Size in accordance with the manufacturer's recommendations. Thunderline Corporation "Link-Seal" sealant assembly.

Floors of Mechanical Rooms, Concrete Walls or Masonry Walls above Grade	Standard weight galvanized steel pipe.

G. Length of sleeves as follows:

Location	Length
Floors	Equal to depth of floor construction including finish. Extend minimum of 1 inch above finished floor level within partitions, mechanical rooms, pipe chases and finished areas. Extend sleeves for non-metallic piping beyond floors or construction as required by the Fire Marshal.
Roofs	Equal to depth of roof construction including insulation. Extend sleeves for non-metallic piping below roof or construction as required by the Fire Marshal.
Exterior Concrete Walls	Equal to depth of construction. Extend sleeves for non-metallic piping beyond walls or construction as required by the Fire Marshal.

H. Firestopping: Provide firestopping assemblies at all pipe penetrations with construction and materials in conformance with the Fire Marshal requirements and the UL Building Materials / Fire Resistive Directory. Fill material to be 3M or equivalent by Dow Corning or Nelson Electric, as approved by Underwriters Laboratories, Inc.

I. Finish and Plates:

1. Smooth up rough edges around sleeve with plaster.
2. Provide 1 inch wide chrome or nickel plated plates on all pipes exposed to view, passing through floors, walls, partitions, plaster furring, etc. Escutcheons shall be sized to fit pipe and pipe covering and give a finished appearance. Escutcheons shall be held in place by setscrews.

J. Seal all penetrations through interior non-rated acoustic walls.

2.8 ESCUTCHEONS

- A. All escutcheons shall be brass, polished chrome-plated.

2.9 GROUT

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

- 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. Pitch: All waste pipes shall be run at 2 percent slope unless for specific locations for 4" and larger can run at min. 1%, where due to structural obstruction or shallow civil connections per CPC 708.0; note on drawings where 1% occurs and describe reasons on drawings.
- C. Water Piping within Walls and Rough-ins for Fixtures and Equipment: Provide copper plated steel support system soldered to piping and secured to building construction so that pipes cannot be displaced. Provide trisolator or fire retardant closed cell elastomeric material between support system and building construction and other piping.
- D. Waste and Vent Piping within Walls and Rough-ins for Fixtures and Equipment: Provide copper plated steel support system for copper DWV piping or galvanized steel support system for cast iron or galvanized piping. Secure supports to piping and building construction so that pipes cannot be displaced. Provide felt strip isolation between dissimilar metals. Provide trisolator or fire retardant closed cell elastomeric material between support system and building construction and other piping.
- E. Piping through walls serving fixtures, equipment and outlets. Provide temporary plastic sleeve installed around piping serving plumbing fixtures, equipment and outlets to provide clearance between the pipe and drywall or plaster construction at the point of pipe penetration. After the plumbing rough-in and drywall installation is completed, the plastic sleeve shall be removed and Type GR fire retardant sponge material installed to seal the pipe penetration.
- F. Provide floor shut off valves where floor mains taking off the main risers for all water and med gas services, in accessible locations.

- G. Unions and Flanges: Provide on piping to inlet and outlet of all apparatus and equipment to facilitate removal of equipment, and downstream of all shutoff valves.
- H. Water Hammer Arresters: Install water hammer arresters at all quick closing valves such as flush valves, float valves, solenoid valves, etc. Size and locate all water hammer arresters as recommended by PDI Manual WH 201.
- I. Water Piping:
 - 1. Cut pipe square, ream full size, and remove all burrs. End of pipe must be thoroughly cleaned to one inch more than the depth of the fitting. Apply a coat of flux and make joint. Consult manufacturer's instructions for application of flux and joining technique. The use of tubing cutters is prohibited.
 - 2. Iron Pipe Size (IPS) Brass Threaded Joints: Cut pipe square and ream full size. Cut threads with new, clean dies to standard tolerance. Make up with Teflon tape to male thread only. Remove exposed excess tape after joint is made.
- J. Provide sleeves with fire rated insulation and resilient fire rated sealant at all pipe penetrations through walls and floors.

3.2 CLEANOUTS

- A. Size: Cleanouts of same nominal size as pipe they serve except where they occur in piping 4 inches and larger, in which case they shall be 4 inches in size.
- B. Accessibility: Make all cleanouts accessible, Use graphite on all cleanouts with all threads being thoroughly greased after acceptable pressure test.
- C. Locations
 - 1. At all horizontal offsets.
 - 2. At ends of all lines more than 5 feet in length.
 - 3. At 100 foot maximum intervals in all horizontal runs within the building lines, unless otherwise shown on the drawings.
 - 4. At base of all stacks.
 - 5. For cleanouts in finished portions of building, locations subject to the Owner's approval before installation.

3.3 PREPARATION

- A. Cut pipe ends square. Ream ends of piping to remove burrs. Clean scale and dirt from interior and exterior of each section of pipe and fitting prior to assembly.

3.4 ERECTION

- A. Install all piping parallel to building walls and ceilings and at heights, which do not obstruct any portion of a window, doorway, stairway, or passageway. Where interferences develop in the field, offset or reroute piping as required to clear such interferences. Coordinate locations of plumbing piping with piping, ductwork, conduit and equipment of other trades to allow sufficient clearances. In all cases, consult drawings for exact location of pipe spaces, ceiling heights, door and window openings, or other architectural details before installing piping.
- B. Where copper or steel piping is embedded in masonry or concrete, provide protective sleeve covering of elastomeric pipe insulation.
- C. Wherever possible in finished and occupied spaces, conceal piping from view by locating in column enclosures, hollow wall construction or above suspended ceilings.
- D. Install underground warning tape 6 inches – 12 inches below finished grade above all exterior below ground piping. Where existing underground warning tape is encountered, repair and replace.
- E. Maintain piping in clean condition internally during construction.
- F. Provide clearance for installation of insulation, access to valves and piping specialties. Where possible, locate insulated piping for 1-inch clearance outside insulation.
- G. Provide anchors, expansion joints, swing joints and/or expansion loops so that piping may expand and contract without damage to itself, equipment, or building.
- H. Mitered ells, notched tees, and orange peel reducers are not acceptable. On threaded piping, bushings are not acceptable.
- I. Do not route piping through transformer vaults or above transformers, panelboards, or switchboards, including the required service space for this equipment, unless the piping is serving this equipment
- J. Install all valves and piping specialties, including items furnished by others, as specified and/or detailed. Provide access to valves and specialties for maintenance. Make connections to all equipment, fixtures and systems installed by others where it requires the piping services indicated in this section.

3.5 COPPER PIPE JOINTS

- A. Remove all slivers and burrs remaining from the cutting operation by reaming and filing both pipe surfaces. Clean fitting and tube with metal brush, emery cloth or sandpaper. Remove residue from the cleaning operation, apply flux and assemble joint to socket stop. Apply flame to fitting until solder melts when placed at joint.

Remove flame and feed solder into joint until full penetration of cup and ring of solder appears. Wipe excess solder and flux from joint.

3.6 WELDED PIPE JOINTS

- A. Make all welded joints by fusion welding in accordance with ASME Codes, ANSI B31, and State Codes where applicable. Electrodes shall be Lincoln, or equal, with coating and diameter as recommended by the manufacturer for the type and thickness of work being done.

3.7 THREADED PIPE JOINTS

- A. Use a thread lubricant or Teflon tape when making joints; no hard setting pipe thread cement or caulking will be allowed.

3.8 PIPING CONNECTIONS

- A. 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. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
 - 4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.9 MECHANICAL HUBLESS PIPE CONNECTIONS

- A. Place the gasket on the end of one pipe or fitting and the clamp assembly on the end of the other pipe or fitting. Firmly seat the pipe or fittings ends against the integrally molded shoulder inside the neoprene gasket. Slide the clamp assembly into position over the gasket. Tighten fasteners to manufacturers recommended torque.

3.10 MECHANICAL JOINT PIPE CONNECTIONS

- A. Clean pipe end and socket. Clean and lubricate pipe end and gasket with soapy water or gasket lubricant. Place gland and gasket, properly oriented, on pipe end. Insert pipe end fully into socket and press gasket evenly into recess keeping joint straight. Press gland evenly against gasket, insert bolts and hand tighten nuts. Make joint

deflection prior to tightening bolts. Evenly tighten bolts in sequence to recommended torque.

3.11 PUSH-ON GASKETED PIPE CONNECTIONS

- A. Clean pipe end, bell, gasket seat and gasket of dirt or debris. Coat end of pipe and gasket with gasket lubricant. Push spigot end into end of gasket bell with levered pipe joining tool recommended by pipe manufacturer. Large diameter exterior mains may be joined by pushing end of pipe section with backhoe against wood blocking over pipe end. Insert to fully seated position or to reference mark on pipe.

3.12 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install plumbing 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.
- D. Install equipment to allow right of way for piping installed at required slope.

3.13 PAINTING

- A. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.
- B. Provide painting for outdoor natural gas piping.

3.14 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - 1. Construct concrete bases of dimensions indicated, but not less than 6 inches larger in both directions than supported unit.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
 - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.

4. Place and secure anchorage devices. Use supported equipment manufacturer's 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.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Section 03 30 00 - Cast-in-Place Concrete.

3.15 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Section 05 50 00 - Metal Fabrications for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.16 GROUTING

- A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases and provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout.

END OF SECTION

SECTION 22 05 17

SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

(Part of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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.

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 STACK-SLEEVE 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. Smith, Jay R. Mfg. Co.
 - 2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.
 - 3. Mifab
- 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, 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.
 6. Link-seal.
- 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] [Plastic] [Stainless steel].
 3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.4 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. Presealed Systems.
 2. Unique Firestop
 3. SpecSeal

- 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.

2.5 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 07 92 00 "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 07 84 13 "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 07 62 00 "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 07 84 13 "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. Using grout, seal the space around outside of sleeve-seal fittings.

3.5 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: Sleeve-seal fittings.
 - b. Piping NPS 6 and Larger: Galvanized-steel wall sleeves.
 - 2. Exterior Concrete Walls below 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.
3. Concrete Slabs-on-Grade:
 - a. Piping Smaller Than NPS 6: [Galvanized-steel-pipe sleeves with sleeve-seal system] [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 6 and Larger: Cast-iron 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.
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. All Pipe Sizes: Galvanized-steel-sheet sleeves.

END OF SECTION

SECTION 22 05 18

ESCUTCHEONS FOR PLUMBING PIPING

(Part of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
- D. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.
- E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

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 insulated 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. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.

- f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - g. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - h. Chrome plated plastic escutcheons are not acceptable.
- 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 22 05 19

METERS AND GAGES FOR PLUMBING PIPING

(Part of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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. Thermometers.
- 2. Gages.
- 3. Test plugs.

- B. Related Sections:

- 1. Division 22 Section "Domestic Water Piping" for domestic and fire-protection water service meters inside the building.

1.3 DEFINITIONS

- A. CR: Chlorosulfonated polyethylene synthetic rubber.
- B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated; include performance curves.

- B. Shop Drawings: Schedule for thermometers and gages indicating manufacturer's number, scale range, and location for each.
- C. Product Certificates: For each type of thermometer and gage, signed by product manufacturer.

PART 2 - PRODUCTS

2.1 METAL-CASE, DIGITAL THERMOMETERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Weiss Instruments, Inc.
 - 2. Watts
 - 3. Wika
 - 4. Approved Equal
- B. Connector: Adjustable type, 360 degrees in horizontal plane, with locking device.
- C. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.
- D. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.2 THERMOWELLS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Weiss Instruments, Inc.
 - 2. Emerson
 - 3. Wika
 - 4. Approved Equal
- B. Manufacturers: Same as manufacturer of thermometer being used.

- C. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.3 PRESSURE GAGES

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

- 1. Weiss Instruments, Inc.
- 2. Watts
- 3. Viking Group Inc.
- 4. Approved Equal

- B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.

- 1. Case: Oil filled, drawn steel or cast aluminum, 4-1/2-inch.
- 2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
- 3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
- 4. Movement: Mechanical, with link to pressure element and connection to pointer.
- 5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- 6. Pointer: Red metal.
- 7. Window: Glass or plastic.
- 8. Accuracy: plus or minus 2 percent of middle half scale.
- 9. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure
- 10. Range for Fluids under Pressure: Two times operating pressure.

- C. Pressure-Gage Fittings:

- 1. Valves: NPS 1/4 brass or stainless-steel needle type.
- 2. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.4 TEST PLUGS

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

1. Flow Design, Inc.
 2. MG Piping Products Co.
 3. National Meter, Inc.
 4. Peterson Equipment Co., Inc.
 5. Sisco Manufacturing Co.
 6. Trerice, H. O. Co.
 7. Watts Industries, Inc.; Water Products Div.
- B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.
- C. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.
- D. Core Inserts: One or two self-sealing rubber valves.
1. Insert material for water service at 20 to 200 deg F shall be CR.
 2. Insert material for water service at minus 30 to plus 275 deg F shall be EPDM.
- E. Test Kit: Furnish one test kit(s) containing one pressure gage and adaptor, one thermometer, and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.
1. Pressure Gage: Small bourdon-tube insertion type with 2- to 3-inch-diameter dial and probe. Dial range shall be 0 to 200 psig.
 2. Low-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch-diameter dial and tapered-end sensing element. Dial ranges shall be 25 to 125 deg F.
 3. High-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch-diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 220 deg F.
 4. Carrying case shall have formed instrument padding.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.
- G. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
- H. Install remote-mounted pressure gages on panel.
- I. Install valve and snubber in piping for each pressure gage for fluids.
- J. Install test plugs in piping tees.
- K. Install thermometers in the following locations:
 - 1. Inlet and outlet of each item of equipment including filters, backflow preventers, meters, and domestic water heat exchangers.
- L. Install pressure gages in the following locations:
 - 1. Building water service entrance into building.
 - 2. Inlet and outlet of each pressure-reducing valve.
 - 3. Suction and discharge of each domestic water pump.

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: 0 to 250 deg F.

3.5 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range for Water Service Piping: 0 to 100 psi.
- B. Scale Range for Domestic Water Piping: 0 to 160 psi.

END OF SECTION

SECTION 22 05 23

GENERAL-DUTY VALVES FOR PLUMBING PIPING

(Part of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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. Ball valves.
- 2. Check valves.
- 3. Grooved-end butterfly valves.

B. Related Sections:

- 1. Division 22 plumbing piping Sections for specialty valves applicable to those Sections only.
- 2. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

1.3 SUBMITTALS

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

1.4 QUALITY ASSURANCE

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 - 1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 2. ASME B31.1 for power piping valves.
 - 3. ASME B31.9 for building services piping valves.
- C. NSF Compliance: NSF 61 for valve materials for potable-water service.

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, grooves, and weld ends.
 - 3. Set angle, gate valves closed to prevent rattling.
 - 4. Set ball and plug valves open to minimize exposure of functional surfaces.
 - 5. Block 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 handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Bronze valves shall be made with dezincification-resistant materials, (Bronze ASTM B62, B61, or B584 Alloy C87850). This includes body, ball, stem and/or trim.
- B. Bronze valves: NPS 2 and smaller with threaded ends, and NPS 2-1/2 and larger with grooved ends unless otherwise noted.
- C. Ferrous valves: NPS 2-1/2 and larger with flanged or grooved ends, unless otherwise indicated.
- D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- F. Valves in Insulated Piping: With 2-1/4" inch stem extensions and the following features:
 - 1. Gate Valves: With rising stem.
 - 2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
- G. Valve-End Connections:
 - 1. Flanged: With flanges according to ASME B16.1 for iron valves.
 - 2. Grooved: With grooves according to AWWA C606.
 - 3. Solder Joint: With sockets according to ASME B16.18.
 - 4. Threaded: With threads according to ASME B1.20.1.
- H. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE BALL VALVES

- A. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim and Nib-Seal Handle (-NS):

1. Basis of Design Product: Subject to compliance with requirements, provide NIBCO Model S-685-80-66-LF (-NS) or T-685-80-66-LF (-NS) or a comparable product by one of the following, but are not limited to, the following:
 - a. Milwaukee Valve Company.
 - b. Nibco
 - c. Watts
 - d. Approved equal
2. Description:
 - a. Standard: MSS SP-110, NSF 61-G.
 - b. CWP Rating: 600 psig.
 - c. Body Design: Two piece with threaded body packnut design (no threaded stem designs allowed) with adjustable stem packing.
 - d. Body Material: Lead free bronze ASTM B283 Alloy C69300.
 - e. Ends: Threaded or solder.
 - f. Seats: PTFE or TFE.
 - g. Stem: 316 stainless steel.
 - h. Ball: 316 stainless steel.
 - i. Port: Full.

2.3 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Non-metallic TFE Disc:

1. Basis of Design Product: Subject to compliance with requirements, provide NIBCO Model S-413-Y-LF or T-413-Y-LF or a comparable product by one of the following:
 - a. Crane Co.; Crane Valve Group; Stockham Division.
 - b. Milwaukee Valve Company.
 - c. Nibco
 - d. Approved Equal

2. Description:

- a. Standard: MSS SP-80, Type 4, NSF 61-G.
- b. CWP Rating: 200 psig.
- c. Body Design: Y-pattern Horizontal flow.
- d. Body Material: ASTM B 584 Alloy C87850, lead free bronze.
- e. Ends: Threaded or solder.
- f. Disc: PTFE or TFE.

2.4 BRONZE, GROOVED-END BUTTERFLY VALVES

A. 300 CWP, Bronze, grooved-end Butterfly Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following, but are not limited to, the following:
 - a. Milwaukee
 - b. Nibco
 - c. ASC engineered solutions
 - d. Engineer Approved Equal
- 2. Description:
 - a. Standard: MSS SP-67, Type I.
 - b. CWP Rating: 300 psig.
 - c. Body Material: Bronze.
 - d. Stem: Integrally cast ductile iron.
 - e. Disc: Aluminum Bronze. Offset
 - f. Seal: Grade P Flouroelastomer rated 0° F to 180° F.

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.
- 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. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

- A. Install valves with unions, grooved joint couplings 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 check valves for proper direction of flow and as follows:
 - 1. Swing Check Valves: In horizontal position with hinge pin level.

3.3 ADJUSTING

- A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
 - 1. Shutoff Service: Ball or butterfly valves.
 - 2. Throttling Service: Globe, butterfly or ball valves.
 - 3. Pump-Discharge Check Valves:
 - 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 with spring or iron, center-guided, metal or resilient-seat check valves.
 - c. NPS 2-1/2 and Larger for Storm Drainage: Iron swing check valves with lever and weight or spring.
- B. If valves with specified CWP ratings are not available, the same types of valves with higher CWP ratings may be substituted.
- C. Select valves, except wafer types, 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. For Copper Tubing, NPS 5 and Larger: Flanged ends.
 - 4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
 - 5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 - 6. For Steel Piping, NPS 5 and Larger: Flanged ends.
 - 7. For Grooved-End Copper Tubing and Steel Piping: Valve ends may be grooved.

3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2-1/2" and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Bronze Angle Valves: Class 150, non-metallic disc.
3. Ball Valves: Two piece, full port, bronze with stainless steel trim.
4. Bronze Swing Check Valves: Class 150, non-metallic TFE disc.

B. Pipe NPS 3" and Larger:

1. Iron Ball Valves: Class 150.
2. Bronze, grooved-end Butterfly Valves: 300 CWP
3. Iron Swing Check Valves: Class 125, metal seats.
4. Iron Swing Check Valves with Closure Control: Class 125, lever and weight.
5. Iron, Grooved-End Swing Check Valves: 300 CWP.
6. Iron, Center-Guided Check Valves: Class 125, globe, resilient seat.
7. Iron, Plate-Type Check Valves: Class 125 dual plate; resilient seat.
8. Iron Gate Valves: Class 125, OS&Y.

3.6 SANITARY-WASTE AND STORM-DRAINAGE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Ball Valves: Two piece, full port, bronze with stainless-steel trim.
3. Bronze Swing Check Valves: Class 125, nonmetallic TFE disc.
4. Bronze Gate Valves: Class 150, RS.

B. Pipe NPS 2-1/2 and Larger:

1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Steel Ball Valves: Class 150, full port.
3. Iron Swing Check Valves: Class 125, metal seats.
4. Iron Swing Check Valves with Closure Control: Class 125, lever and weight.
5. Iron, Grooved-End Swing Check Valves: 300 CWP.
6. Iron Gate Valves: Class 125, OS&Y.

7. Lubricated Plug Valves: Class 250, regular gland.

END OF SECTION

SECTION 22 05 29

HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

(Part of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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 includes the following hangers and supports for plumbing system piping and equipment:
 - 1. Steel pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Thermal-hanger shield inserts.
 - 4. Fastener systems.
 - 5. Pipe stands.
 - 6. Pipe positioning systems.
 - 7. Equipment supports.
- B. Related Sections include the following:
 - 1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
 - 2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-suppression piping.
 - 3. Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.3 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.4 SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel pipe hangers and supports.
 - 2. Thermal-hanger shield inserts.
 - 3. Powder-actuated fastener systems.
 - 4. Pipe positioning systems.
- B. 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. Include Product Data for components.
 - 2. Metal framing systems. Include Product Data for components.
 - 3. Pipe stands. Include Product Data for components.
 - 4. Equipment supports.
- C. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel." ASME Boiler and Pressure Vessel Code: Section IX.
- B. Welding: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1, "Structural Welding Code--Steel."
 - 2. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
 - 3. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 STEEL PIPE HANGERS AND SUPPORTS

- A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.
- B. Manufacturers:
 - 1. B-Line Systems, Inc.; a division of Cooper Industries.
 - 2. Grinnell Corp.
 - 3. Tolco Inc.
 - 4. Or approved equal.
- C. Galvanized, Metallic Coatings: Pre-galvanized or hot dipped.
- D. Non-metallic Coatings: Plastic coating, jacket, or liner.
- E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.
- F. All hangers to be factory painted except exterior hangers and supports which shall be hot dipped galvanized.

2.3 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.4 METAL FRAMING SYSTEMS

- A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.
- B. Manufacturers:
 - 1. B-Line Systems, Inc.; a division of Cooper Industries.
 - 2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
 - 3. GS Metals Corp.
 - 4. Power-Strut Div.; Tyco International, Ltd.
 - 5. Thomas & Betts Corporation.
 - 6. Tolco Inc.
 - 7. Unistrut Corp.; Tyco International, Ltd.
 - 8. Or approved equal.
- C. Coatings: Manufacturer's standard finish unless bare metal surfaces are indicated.
- D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.5 THERMAL-HANGER SHIELD INSERTS

- A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.
- B. Manufacturers:
 - 1. Carpenter & Paterson, Inc.
 - 2. ERICO/Michigan Hanger Co.
 - 3. PHS Industries, Inc.
 - 4. Pipe Shields, Inc.
 - 5. Rilco Manufacturing Company, Inc.
 - 6. Value Engineered Products, Inc.
 - 7. Or approved equal.
- C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.
- D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.

- E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

- A. Mechanical-Expansion Anchors: Insert-wedge-type stainless steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - 1. Manufacturers:
 - a. B-Line Systems, Inc.; a division of Cooper Industries.
 - b. Empire Industries, Inc.
 - c. Hilti, Inc.
 - d. ITW Ramset/Red Head.
 - e. MKT Fastening, LLC.
 - f. Powers Fasteners.
 - g. Or approved equal.
- B. Fasteners to CLT: Minimum 1/4" diameter SWG ASSY 3/0 wood screw x 3-1/2" length spaced no closer than 3" o.c. and no closer than 6" from all edges. Max allowable load per screw to equal 200 lb.
 - 1. Manufacturers:
 - a. Myticon Timber Connectors Inc.
 - b. Simpson Strong-Tie
 - c. Eaton
 - d. Or approved equal

2.7 PIPE POSITIONING SYSTEMS

- A. Description: IAPMO PS 42, system of metal brackets, clips, and straps for positioning piping in pipe spaces for plumbing fixtures for commercial applications.
- B. Manufacturers:
 - 1. HOLDRITE Corp.; Hubbard Enterprises.
 - 2. ASC Engineered Solutions
 - 3. Or approved equal.

2.8 EQUIPMENT SUPPORTS

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

2.9 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36, 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: Non-staining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 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 padded hangers for piping that is subject to scratching.
- F. 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 non-insulated or insulated stationary pipes, NPS 1/2 to NPS 30.
 - 2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
 - 3. 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.
 - 4. 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.
 - 5. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of non-insulated stationary pipes, NPS 3/4 to NPS 8.
 - 6. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 2.
 - 7. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
 - 8. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 - 9. 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.
 - 10. 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.
 - 11. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.
- G. 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 20.
 - 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.

- H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
- I. 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-joist 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.

- J. 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.
- K. 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 absorb 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 absorb 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 absorb 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.
- L. Comply with MSS SP-69 for trapeze pipe hanger 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.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Steel 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 building structure.
- B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. 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 above for individual pipe hangers.
 - 2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
- C. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- D. Fastener System Installation:
 - 1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- E. Pipe Positioning System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. Refer to Division 22 Section "Plumbing Fixtures" for plumbing fixtures.
- F. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

- H. 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.
- I. Install lateral bracing with pipe hangers and supports to prevent swaying.
- J. 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.
- K. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.
- M. Insulated Piping: Comply with the following:
 - 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 according to 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 inserts.
- 6. Insert Material: Length at least as long as protective shield.
- 7. Thermal-Hanger Shields: Install with insulation 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 smooth bearing surface.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

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. Touch Up: 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 minimum dry film thickness of 2.0 mils.
- B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 Painting Sections.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 22 05 48

VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

(Part of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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 supports.
 - 9. Resilient pipe guides.
 - 10. Elastomeric hangers.

11. Spring hangers.
12. Snubbers.
13. Restraint channel bracings.
14. Restraint cables.
15. Seismic-restraint accessories.
16. Mechanical anchor bolts.
17. Adhesive anchor bolts.

B. Related Requirements:

1. Section 21 05 48 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" for devices for fire-suppression equipment and systems.
2. Section 23 05 48 "Vibration and Seismic Controls for HVAC" for devices for HVAC equipment and systems.

1.3 DEFINITIONS

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.

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. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.
 - a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.

- b. Annotate to indicate application of each product submitted and compliance with requirements.
- 3. 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.
- C. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.
 - 1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 2. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, due to seismic forces required to select vibration isolators, and due to seismic restraints.
 - 3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
 - 4. Seismic-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

- c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
- d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing 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. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.
- B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Site Class as Defined in 780 CMR: D
2. Assigned Seismic Use Group or Building Category as Defined in 780 CMR: C.
 - a. Component Importance Factor: 1.5
 - b. Component Response Modification Factor: 3 in accordance with ASCE/SEI 7-05.
3. Design Spectral Response Acceleration at Short Periods (0.2 Second): in accordance with 780 CMR and ASCE/SEI 7-05.
4. Design Spectral Response Acceleration at 1-Second Period: (0.069) in accordance with 780 CMR and ASCE/SEI 7-05.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Vibration Eliminator Co., Inc.
 - g. Vibration Isolation.
 - h. 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. Pad Material: Oil and water resistant with elastomeric properties..
5. Infused nonwoven cotton or synthetic fibers.
6. Load-bearing metal plates adhered to pads.
7. Sandwich-Core Material: [Resilient] [and] [elastomeric].
 - a. Surface Pattern: [Smooth] [Ribbed] [Waffle] pattern.
 - b. Infused nonwoven cotton or synthetic fibers.

2.3 ELASTOMERIC ISOLATION MOUNTS

A. Double-Deflection, Elastomeric Isolation Mounts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Vibration Eliminator Co., Inc.
 - g. Vibration Isolation.
 - h. 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. 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. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Vibration Eliminator Co., Inc.
 - g. Vibration Isolation.
 - h. Vibration Mountings & Controls, Inc.
2. Description: All-directional isolator with seismic 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.

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. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.

- f. Vibration Eliminator Co., Inc.
 - g. Vibration Isolation.
 - h. 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 psig.
- 7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

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. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Vibration Eliminator Co., Inc.
 - g. Vibration Isolation.
 - h. 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. 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 psig
 - b. Top housing with 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. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Vibration Eliminator Co., Inc.
 - g. Vibration Isolation.
 - h. 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 psig
 - b. Top plate with 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.

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. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Vibration Eliminator Co., Inc.
 - g. Vibration Isolation.
 - h. 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 psig
 - 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.

2.9 PIPE-RISER RESILIENT SUPPORT

- A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch- thick neoprene
 1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
 2. Maximum Load Per Support: 500 psig on isolation material providing equal isolation in all directions.

2.10 RESILIENT PIPE GUIDES

- A. Description: Telescopic arrangement of two steel tubes or post and sleeve arrangement separated by a minimum 1/2-inch- thick neoprene.
 1. 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 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. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Vibration Eliminator Co., Inc.
 - g. 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. Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

2.12 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. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Kinetics Noise Control, Inc.
 - d. Mason Industries, Inc.
 - e. Vibration Eliminator Co., Inc.

- f. Vibration Isolation.
 - g. 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. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - 7. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
 - 8. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
 - 9. Self-centering hanger-rod cap to ensure concentricity between hanger rod and support spring coil.

2.13 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. 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. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch air gap, and minimum 1/4-inch- thick resilient cushion.

2.14 RESTRAINT CHANNEL BRACINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Cooper B-Line, Inc.
 2. Hilti, Inc.
 3. Mason Industries, Inc.
 4. Unistrut.
- B. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with 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.

2.15 RESTRAINT CABLES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Kinetics Noise Control, Inc.
 2. Loos & Co., Inc.
 3. Vibration Mountings & Controls, Inc.
- B. Restraint Cables: ASTM A 603 galvanized steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.16 SEISMIC-RESTRAINT ACCESSORIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper B-Line, Inc.
 - 2. Kinetics Noise Control, Inc.
 - 3. Mason Industries, Inc.
 - 4. TOLCO.
- B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections 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.

2.17 MECHANICAL ANCHOR BOLTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper B-Line, Inc.
 - 2. Hilti, Inc.
 - 3. Kinetics Noise Control, Inc.
 - 4. Mason Industries, Inc.

- B. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.18 ADHESIVE ANCHOR BOLTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Hilti, Inc.
 - 2. Kinetics Noise Control, Inc.
 - 3. Mason Industries, Inc.
- B. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and seismic-control 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 by an agency acceptable to authorities having jurisdiction.

- B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

- A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 03 30 00 "Cast-in-Place Concrete".
- B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.
- C. Comply with requirements in Section 07 72 00 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- D. Equipment Restraints:
 - 1. Install seismic 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.
 - 3. Install seismic-restraint devices using methods approved an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- E. 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

- F. Install cables so they do not bend across edges of adjacent equipment or building structure.
- G. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- H. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- I. 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.
- J. 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.
- K. Drilled-in 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 the 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. Wedge Anchors: 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 Anchors: 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 SEISMIC MOTION

- A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 22 11 16 "Domestic Water Piping" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:
 - 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 - 2. 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.
 - 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 - 4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 - 5. Test to 90 percent of rated proof load of device.
 - 6. Measure isolator restraint clearance.
 - 7. Measure isolator deflection.
 - 8. Verify snubber minimum clearances.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust isolators after piping 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.

END OF SECTION

SECTION 22 05 53

IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

(Part of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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. Valve tags.
 - 5. 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.

1.4 COORDINATION

- 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.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
 - 1. Material and Thickness: Brass, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 - 3. 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-fourths the size of principal lettering.
 - 4. Fasteners: Stainless-steel rivets or self-tapping screws (Note-Plastic zip-tie or tie-wrap are not approved for use as a fastener).
 - 5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
 2. Letter Color: Black.
 3. Background Color: White.
 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F
 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 or 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-fourths the size of principal lettering.
 7. Fasteners: Stainless-steel rivets or self-tapping screws.
 8. 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), plus 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), plus 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. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving 1/8 inch thick, and having predrilled holes for attachment hardware.
- B. Letter Color: White.
- C. Background Color: Red.

- D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- F. 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-fourths the size of principal lettering.
- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- 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. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pre-tensioned Pipe Labels: Pre-coiled, semirigid plastic formed cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, 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 1-1/2 inches high.

2.4 VALVE TAGS

- A. 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 or beaded chain
- B. 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. Warning Tags: 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: 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 EQUIPMENT LABEL INSTALLATION

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

3.3 PIPE LABEL INSTALLATION

- A. Piping Color-Coding: Painting of piping is specified in Section 09 91 23 "Interior Painting." and Section 09 96 00 "High-Performance Coatings."
- B. 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.
- C. Pipe Label Color Schedule:
 - 1. Compressed-Air Piping:
 - a. Background Color: White & Yellow checkerboard.
 - b. Letter Color: Black.
 - 2. Domestic Water Piping:
 - a. Background Color: Green.

- b. Letter Color: White.

3. Sanitary Waste and Storm Drainage Piping:

- a. Background Color: green.
- b. Letter Color: white.

3.4 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.
 - c. Compressed Air: 2 inches, round.
 - 2. Valve-Tag Color:
 - a. Cold Water: Natural.
 - b. Hot Water: Natural.
 - c. Compressed Air: Natural.
 - 3. Letter Color:
 - a. Cold Water: Black.
 - b. Hot Water: Black.
 - c. Compressed Air: Black].

3.5 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 of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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. Storm-water piping exposed to freezing conditions.
- 6. Roof drains and rainwater leaders.

- B. Related Sections:

- 1. Division 22 Section "Plumbing 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. 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. Insulation Materials: Insulation materials must be manufactured at facilities certified and registered with an approved registrar to conform to ISO 9001 Quality Standards.
 - 1. Pipe insulation shall be pre-formed and furnished in standard lengths with ends cut square, conforming to the dimensional requirements of ASTM C-585.
 - 2. Insulation materials shall be asbestos free.
- B. 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.
- C. 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.
- D. Workmanship: All insulation to be installed by a licensed applicator and applied in accordance with the manufacturer's recommendations.
 - 1. All work shall comply with all federal, state and local codes and laws. This shall include, but not be limited to, the Occupational Safety and Health Act.
 - 2. All work shall conform to accepted industry and trade standards for commercial and industrial insulations.
 - 3. Surfaces to be insulated shall be clean and free of dirt, scale, moisture, oil and grease.

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.
- B. Delivery: Deliver all materials to the jobsite and protect the insulation against dirt, water, chemicals, and mechanical damage before, during and after installation. DO NOT install damaged insulation. Remove damaged insulation from the jobsite. Damaged insulation shall be replaced at the contractor's expense.
 - 1. Deliver insulation, coverings, cements, adhesives, coatings, etc. to the site in factory fabricated containers with the manufacturers stamp and label affixed showing fire hazard ratings of the products.
- C. Installed insulation which has not been weatherproofed shall be protected from inclement weather by approved weatherproof sheeting installed by the contractor. Any wet or damaged insulation shall be removed from the jobsite and replaced by the contractor at no additional cost.

1.7 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 22 Section "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 PIPE INSULATION

- A. All piping shall be insulated with a preformed fiberglass pipe insulation, complying with ASTM C 547, Class 3, rigid, molded pipe insulation, noncombustible.
 - 1. Thermal Conductivity ("k"): 0.23 Btu•in/(hr•ft²•°F) at 75°F mean temperature per ASTM C 518.
 - 2. Maximum Service Temperature: 850°F.
 - 3. Rated 25/50 per ASTM E 84, UL 723 and NFPA 255.
 - 4. When being used over stainless steel, product must comply with the requirements of ASTM C 795.
 - 5. All-Service (ASJ) Vapor-Retarder Jacket: A white, kraft paper, reinforced with a glass fiber yarn and bonded to an aluminum foil, with self-sealing longitudinal closure laps (SSL) and butt strips.
- B. Field-Applied Jackets:
 - 1. PVC Plastic: Zeston® 2000 Series. One piece, molded type fitting covers and jacketing material, custom color selected by architect.
 - a. Connections: Tacks, pressure sensitive, color matching, vinyl tape.
 - 2. Aluminum Jacket: 0.016" thick sheet, (smooth/ embossed) finish, with longitudinal slip joints and 2" laps, die-shaped fitting covers with factory-attached protective liner.
 - 3. Stainless Steel Jacket: Type 304 stainless steel, 0.10", (smooth/ corrugated) finish.

2.2 Fittings, Valves, Tees, etc.

- A. All fittings, valves, tees, flanges, connections, etc. shall be insulated and covered with the appropriate Zeston 2000 PVC insulated fitting cover.
 - 1. Fittings shall be manufactured from ultraviolet-resistant PVC.

2. Connections: Tacks, pressure sensitive, color matching, vinyl tape, Perma-Weld® Adhesive.

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 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.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat -tracing that apply to insulation.
- C. 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. All pipe insulation shall be continuous through wall and ceiling openings and sleeves, except where fire stop materials are required.
- B. Insulation on all cold surfaces must be applied with a continuous, unbroken vapor seal. Hangers, supports, anchors, etc., that are secured directly to cold surfaces must be adequately insulated and vapor sealed to prevent condensation. In brine or chilled water piping systems, seal pipe terminations every four pipe sections.
- C. All surface finishes are to be extended to protect all surfaces, ends and raw edges of insulation.
- D. Rigid insulation inserts shall be installed on pipe sizes 1½" (38 mm) or larger under outside hangers. Inserts shall be of equal thickness to the adjoining insulation and shall be provided with vapor retarder seals where required.
- E. Insulation inserts shall not be less than the following lengths:
 - 1. Pipe Size Length
 - a. in. in. mm
 - b. 1½ – 2½, 10
 - c. 3 – 6, 12
 - d. 8 – 10, 16
 - e. 12 & up, 22
- F. Galvanized metal shields shall be applied between hangers or supports and the pipe insulation. Shields shall be formed to fit the insulation and shall extend up to the centerline of the pipe and the length specified for the insulation hanger inserts less than 4" to allow for vapor retarding butt joints on each side of the shields.
- G. Specified adhesives, mastics and coatings shall be applied at the manufacturer's recommended minimum coverage per gallon.
- H. Indoor piping: This portion of the installation procedure is applicable for piping in all indoor areas, including concealed spaces, mechanical rooms and inhabited areas.
 - 1. Preformed fiber glass pipe insulation with all service jacket (ASJ) shall be applied to piping with all joints tightly fitted to eliminate voids.

2. Longitudinal jacket laps and butt strips shall be smoothly secured according to manufacturer's recommendations.
 3. When adhered, the lap and butt strips must be pressurized by rubbing firmly with a plastic squeegee or the back of a knife blade to ensure positive closure.
 4. The installed thickness shall be enough that the surface temperature shall be kept below 150°F.
 5. For pipe exposed in mechanical equipment rooms or in finished spaces less than 10' above finished floor, finish with Zeston 2000 Cut & Curled™ PVC or aluminum jacket.
 6. Fittings, valves and flanges shall be insulated with Zeston 2000 PVC insulated fitting covers and Hi-Lo® Temp insulation inserts per manufacturer's recommendations.
- I. Outdoor piping systems operating up to 850°F:
1. Plain pipe insulation shall be wired or taped in place over clean, dry pipe with all joints firmly butted together. If a vapor retarder is required, jacket shall be used.
 2. The insulation shall be finished using a metal jacketing with a laminated moisture retarder or with Zeston 2000 PVC jacketing in 20 or 30 mil thicknesses. Metal jacketing shall be overlapped 2" to 3" and held in place with sheet metal screws or metal bands. The Zeston 2000 PVC jacketing shall be secured by overlapping and sealing all joints with Zeston Perma-Weld solvent welding adhesive, per manufacturer's recommended installation procedures.
 3. Elbows and tees for metal-jacketed systems shall be finished with matching metal fitting covers. Other fittings in metal-jacketed systems shall be finished using conventional weather-resistant insulation materials with painted aluminum finish.
 4. When Zeston 2000 PVC Insulated Fitting Covers are used, care shall be taken to ensure that the surface temperature of the fitting will be kept below 150°F by the use of a proper thickness of insulation and by keeping the PVC cover away from contact with, or exposure to, sources of direct or radiant heat.

- J. 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.
- K. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- L. 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.
- M. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- N. Install multiple layers of insulation with longitudinal and end seams staggered.
- O. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- P. Keep insulation materials dry during application and finishing.
- Q. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- R. Install insulation with least number of joints practical.
- S. 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.
- T. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- U. 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.
- V. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- W. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- X. 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.
- Y. 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 Division 07 Section "Penetration Firestopping" for fire-stopping 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 Division 07 Section "Penetration Fire-stopping."

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 FIELD-APPLIED JACKET INSTALLATION

- A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. 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.

3.7 FINISHES

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.
 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.

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. 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.
- D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.9 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.

3.10 INDOOR PIPING INSULATION SCHEDULE

A. Domestic and Non-Potable Cold Water:

1. NPS 1 and Smaller: Insulation shall be the following:
 - a. Fiberglass, Preformed Pipe Insulation: 1/2 inch thick.
2. NPS 1-1/2 and Larger: Insulation shall be the following:
 - a. Fiberglass, Preformed Pipe Insulation: 1 inch thick.

B. Domestic Hot, Non-Potable and Recirculated Hot Water:

1. NPS 1-1/2 and Smaller: Insulation shall be the following:
 - a. Fiberglass, Preformed Pipe Insulation: 1-1/2 inch thick.
2. NPS 2 and Larger: Insulation shall be the following:
 - a. Fiberglass, Preformed Pipe Insulation: 2 inch thick.

C. Domestic Chilled Water (Potable):

1. All Pipe Sizes: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

D. Stormwater and Overflow:

1. All Pipe Sizes vertical and horizontal: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

E. Roof Drain and Overflow Drain Bodies:

1. All Pipe Sizes: Insulation shall be the following:
 - a. Fiberglass, Preformed Pipe Insulation: 1 inch thick.

F. Sanitary Waste Piping Where Heat Tracing Is Installed:

1. All Pipe Sizes: Insulation shall be the following:
 - a. Fiberglass, Preformed Pipe Insulation 1-1/2 inches thick.
- G. 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. Fiberglass, Preformed Pipe Insulation: 1/2 inch thick.
- 3.11 OUTDOOR (AND APPARATUS BAY), ABOVEGROUND PIPING INSULATION SCHEDULE
 - A. Domestic Water Piping:
 1. All Pipe Sizes: Insulation shall be the following:
 - a. Fiberglass, Preformed Pipe Insulation: 2 inches thick.
 - B. Domestic Hot and Non-Potable Hot and Recirculated Hot Water:
 1. All Pipe Sizes: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation: 2 inches thick.
 - C. Sanitary Waste Piping Where Heat Tracing Is Installed:
 1. All Pipe Sizes: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation: 2 inches thick.
- 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. Piping, Concealed:
 1. ASJ
 - D. Piping, Exposed:

1. PVC: 30 mils thick.

3.13 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. Aluminum, Corrugated: 0.040 inch thick.
- D. Piping, Exposed:
 1. Aluminum, Corrugated: 0.040 inch thick.

END OF SECTION

SECTION 22 11 13

FACILITY WATER DISTRIBUTION PIPING

(Part of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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 includes water-distribution piping and related components outside the building for water service and fire-service mains.
- B. Utility-furnished products include water meters that will be furnished to the site, ready for installation.

1.3 DEFINITIONS

- A. EPDM: Ethylene propylene diene terpolymer rubber.
- B. LLDPE: Linear, low-density polyethylene plastic.
- C. PA: Polyamide (nylon) plastic.
- D. PE: Polyethylene plastic.
- E. PP: Polypropylene plastic.
- F. PVC: Polyvinyl chloride plastic.
- G. RTRF: Reinforced thermosetting resin (fiberglass) fittings.

- H. RTRP: Reinforced thermosetting resin (fiberglass) pipe.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.
 - 1. Wiring Diagrams: Power, signal, and control wiring for alarms.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: For piping and specialties including relation to other services in same area, drawn to scale. Show piping and specialty sizes and valves, meter and specialty locations, and elevations.
- B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For water valves and specialties to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. Comply with requirements of utility company supplying water. Include tapping of water mains and backflow prevention.
 - 2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
 - 3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.
- B. Piping materials shall bear label, stamp, or other markings of specified testing agency.

- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with ASTM F 645 for selection, design, and installation of thermoplastic water piping.
- E. Comply with FMG's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.
- F. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.
- G. NSF Compliance:
 - 1. Comply with NSF 14 for plastic potable-water-service piping. Include marking "NSF-pw" on piping.
 - 2. Comply with NSF 61 for materials for water-service piping and specialties for domestic water.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:
 - 1. Ensure that valves are dry and internally protected against rust and corrosion.
 - 2. Protect valves against damage to threaded ends and flange faces.
 - 3. Set valves in best position for handling. Set valves closed to prevent rattling.
- B. During Storage: Use precautions for valves, including fire hydrants, according to the following:
 - 1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
 - 2. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

- C. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use hand wheels or stems as lifting or rigging points.
- D. Deliver piping 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.
- E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.
- F. Protect flanges, fittings, and specialties from moisture and dirt.
- G. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.9 PROJECT CONDITIONS

- A. Interruption of Existing Water-Distribution 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 water-distribution service according to requirements indicated:
 - 1. Notify Owner no fewer than five days in advance of proposed interruption of service.
 - 2. Do not proceed with interruption of water-distribution service without Owner's written permission.

1.10 COORDINATION

- A. Coordinate connection to water main with utility company.

PART 2 - PRODUCTS

2.1 DUCTILE-IRON PIPE AND FITTINGS

- A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.

1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
- B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.
1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 2. Gaskets: AWWA C111, rubber.
- C. Grooved-Joint, Ductile-Iron Pipe: AWWA C151, with cut, rounded-grooved ends.
1. Grooved-End, Ductile-Iron Pipe Appurtenances:
 - a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Anvil International, Inc.
 - 2) Victaulic Company of America.
 - 3) McWane Ductile.
 - b. Grooved-End, Ductile-Iron Fittings: ASTM A 47/A 47M, malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions matching pipe.
 - c. Grooved-End, Ductile-Iron-Piping Couplings: AWWA C606, for ductile-iron-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.
- D. Flanges: ASME 16.1, Class 125, cast iron.

2.2 JOINING MATERIALS

- A. Refer to Section 33 05 00 "Common Work Results for Utilities" for commonly used joining materials.
- B. Brazing Filler Metals: AWS A5.8, BCuP Series.

- C. Bonding Adhesive for Fiberglass Piping: As recommended by fiberglass piping manufacturer.
- D. Plastic Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

2.3 PIPING SPECIALTIES

- A. Transition Fittings: Manufactured fitting or coupling same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.
- B. Tubular-Sleeve Pipe Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cascade Waterworks Manufacturing.
 - b. Dresser, Inc.; Dresser Piping Specialties.
 - c. Ford Meter Box Company, Inc. (The); Pipe Products Div.
 - d. Hays Fluid Controls; a division of ROMAC Industries Inc.
 - e. JCM Industries.
 - f. Smith-Blair, Inc.
 - g. Viking Johnson.
 - 2. Description: Metal, bolted, sleeve-type, reducing or transition coupling, with center sleeve, gaskets, end rings, and bolt fasteners and with ends of same sizes as piping to be joined.
 - a. Standard: AWWA C219.
 - b. Center-Sleeve Material: Manufacturer's standard.
 - c. Gasket Material: Natural or synthetic rubber.
 - d. Pressure Rating: 200 psig minimum.
 - e. Metal Component Finish: Corrosion-resistant coating or material.
- C. Split-Sleeve Pipe Couplings:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Victaulic Depend-O-Lok.
 2. Description: Metal, bolted, split-sleeve-type, reducing or transition coupling with sealing pad and closure plates, O-ring gaskets, and bolt fasteners.
 - a. Standard: AWWA C219.
 - b. Sleeve Material: Manufacturer's standard.
 - c. Sleeve Dimensions: Of thickness and width required to provide pressure rating.
 - d. Gasket Material: O-rings made of EPDM rubber, unless otherwise indicated.
 - e. Pressure Rating: 200 psig minimum.
 - f. Metal Component Finish: Corrosion-resistant coating or material.
- D. Flexible Connectors:
1. Nonferrous-Metal Piping: Bronze hose covered with bronze wire braid; with copper-tube, pressure-type, solder-joint ends or bronze flanged ends brazed to hose.
 2. Ferrous-Metal Piping: Stainless-steel hose covered with stainless-steel wire braid; with ASME B1.20.1, threaded steel pipe nipples or ASME B16.5, steel pipe flanges welded to hose.
- E. 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. Description:
 - 1) Standard: ASSE 1079.
 - 2) Pressure Rating: 250 psig.

- 3) End Connections: Solder-joint copper alloy and threaded ferrous.

3. Dielectric Flanges:

a. Description:

- 1) Standard: ASSE 1079.
- 2) Factory-fabricated, bolted, companion-flange assembly.
- 3) Pressure Rating: 300 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-Flange Insulating Kits:

a. Description:

- 1) Nonconducting materials for field assembly of companion flanges.
- 2) Pressure Rating: 150 psig.
- 3) Gasket: Neoprene or phenolic.
- 4) Bolt Sleeves: Phenolic or polyethylene.
- 5) Washers: Phenolic with steel backing washers.

5. Dielectric Nipples:

a. Description:

- 1) Standard: IAPMO PS 66
- 2) Electroplated steel nipple. complying with ASTM F 1545.
- 3) Pressure Rating: 300 psig at 225 deg F.
- 4) End Connections: Male threaded or grooved.
- 5) Lining: Inert and noncorrosive, propylene.

2.4 GATE VALVES

A. AWWA, Cast-Iron Gate Valves:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

FACILITY WATER DISTRIBUTION PIPING

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Cast Iron Pipe Co.; American Flow Control Div.
 - b. Crane Co.; Crane Valve Group; Stockham Div.
 - c. McWane, Inc.; Kennedy Valve Div.
 - d. McWane, Inc.; Tyler Pipe Div.; Utilities Div.
 - e. NIBCO INC.
 - f. Approved equal
3. Non-rising-Stem, Metal-Seated Gate Valves:
 - a. Description: Gray- or ductile-iron body and bonnet; with cast-iron or bronze double-disc gate, bronze gate rings, bronze stem, and stem nut.
 - 1) Standard: AWWA C500.
 - 2) Minimum Pressure Rating: 200 psig.
 - 3) End Connections: Mechanical joint.
 - 4) Interior Coating: Complying with AWWA C550.
4. Non-rising-Stem, Resilient-Seated Gate Valves:
 - a. Description: Gray- or ductile-iron body and bonnet; with bronze or gray- or ductile-iron gate, resilient seats, bronze stem, and stem nut.
 - 1) Standard: AWWA C509.
 - 2) Minimum Pressure Rating: 200 psig.
 - 3) End Connections: Mechanical joint.
 - 4) Interior Coating: Complying with AWWA C550.
5. Non-rising-Stem, High-Pressure, Resilient-Seated Gate Valves:
 - a. Description: Ductile-iron body and bonnet; with bronze or ductile-iron gate, resilient seats, bronze stem, and stem nut.
 - 1) Standard: AWWA C509.
 - 2) Minimum Pressure Rating: 250 psig.
 - 3) End Connections: Push on or mechanical joint.

- 4) Interior Coating: Complying with AWWA C550.
- 6. OS&Y, Rising-Stem, Metal-Seated Gate Valves:
 - a. Description: Cast- or ductile-iron body and bonnet, with cast-iron double disc, bronze disc and seat rings, and bronze stem.
 - 1) Standard: AWWA C500.
 - 2) Minimum Pressure Rating: 200 psig.
 - 3) End Connections: Flanged.
- 7. OS&Y, Rising-Stem, Resilient-Seated Gate Valves:
 - a. Description: Cast- or ductile-iron body and bonnet, with bronze or gray- or ductile-iron gate, resilient seats, and bronze stem.
 - 1) Standard: AWWA C509.
 - 2) Minimum Pressure Rating: 200 psig.
 - 3) End Connections: Flanged.
- B. Bronze Gate Valves:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Crane Co.; Crane Valve Group; Stockham Div.
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.
 - e. Approved Equal
 - 2. OS&Y, Rising-Stem Gate Valves:
 - a. Description: Bronze body and bonnet and bronze stem.
 - 1) Standards: UL 262 and FMG approved.
 - 2) Minimum Pressure Rating: 175 psig.
 - 3) End Connections: Threaded.

3. Non-rising-Stem Gate Valves:

- a. Description: Class 125, Type 1, bronze with solid wedge, threaded ends, and malleable-iron handwheel.
 - 1) Standard: MSS SP-80.

2.5 CHECK VALVES

A. AWWA Check Valves:

- 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. American Cast Iron Pipe Co.; American Flow Control Div.
 - b. Crane Co.; Crane Valve Group; Stockham Div.
 - c. McWane, Inc.; Kennedy Valve Div.
 - d. NIBCO INC.
 - e. Watts Water Technologies, Inc.
 - f. Approved equal
- 2. Description: Swing-check type with resilient seat. Include interior coating according to AWWA C550 and ends to match piping.
 - a. Standard: AWWA C508.
 - b. Pressure Rating: 175 psig.

2.6 BUTTERFLY VALVES

A. AWWA Butterfly Valves:

- 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Mueller Co.; Water Products Div.

- b. Pratt, Henry Company.
 - c. Val-Matic Valve & Manufacturing Corp.
- 3. Description: Rubber seated.
 - a. Standard: AWWA C504.
 - b. Body: Cast or ductile iron.
 - c. Body Type: Wafer or flanged.
 - d. Pressure Rating: 150 psig.

2.7 WATER METERS

- A. Water meters will be furnished by utility company.
- B. Manufacturers:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. AMCO Water Metering Systems.
 - b. Badger Meter, Inc.
 - c. Carlon Meter.
 - d. Hays Fluid Controls; a division of ROMAC Industries Inc.
 - e. McCrometer.
 - f. Mueller Co.; Hersey Meters.
 - g. Neptune Technology Group Inc.
 - h. Sensus Metering Systems.
- C. Turbine-Type Water Meters:
 - 1. Description:
 - a. Standard: AWWA C701.
 - b. Registration: Flow in cubic feet.
- D. Compound-Type Water Meters:

1. Description:
 - a. Standard: AWWA C702.
 - b. Registration: Flow in cubic feet.

E. Remote Registration System:

1. Description: Utility company standard; encoder type. Include meter modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly.
 - a. Standard: AWWA C707.
 - b. Registration: Flow in cubic feet.
 - c. Data-Acquisition Units: Comply with utility company requirements for type and quantity.
 - d. Visible Display Units: Comply with utility company requirements for type and quantity.

2.8 PRESSURE-REDUCING VALVES

A. Water Regulators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cash Acme; a division of The Reliance Worldwide Corporation.
 - b. Conbraco Industries, Inc.
 - c. Honeywell Water Controls.
 - d. Watts Water Technologies, Inc.
 - e. Wilkins; a Zurn company.
2. Standard: ASSE 1003.
3. Pressure Rating: Initial pressure of 150 psig (1035 kPa).
4. Body: Bronze[with chrome-plated finish for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).

5. Valves for Booster Heater Water Supply: Include integral bypass.
6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

2.9 RELIEF VALVES

A. Air-Release Valves:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Crispin-Multiplex Manufacturing Co.
 - b. GA Industries, Inc.
 - c. Val-Matic Valve & Manufacturing Corp.
2. Description: Hydromechanical device to automatically release accumulated air.
 - a. Standard: AWWA C512.
 - b. Pressure Rating: 300 psig.
 - c. Body Material: Cast iron.
 - d. Trim Material: Stainless steel, brass, or bronze.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Refer to Section 31 20 00 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

- A. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.
- B. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.

- C. Do not use flanges or unions for underground piping.
- D. Flanges, unions, grooved-end-pipe couplings, and special fittings may be used, instead of joints indicated, on aboveground piping and piping in vaults.
- E. Underground water-service piping NPS 4 to NPS 8 shall be any of the following:
 - 1. Ductile-iron, grooved-end pipe; ductile-iron-pipe appurtenances; and grooved joints.

3.3 VALVE APPLICATIONS

- A. General Application: Use mechanical-joint-end valves for NPS 3 and larger underground installation. Use threaded- or flanged-end valves for installation in vaults. Use UL/FMG, nonrising-stem gate valves for installation with indicator posts. Use corporation valves and curb valves with ends compatible with piping, for NPS 2 and smaller installation.

3.4 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. See Section 33 11 13.13 "Ductile Iron Pipe and Fittings for Water Mains" for piping-system.

3.5 PIPING INSTALLATION

- A. Water-Main Connection: Arrange with utility company for tap of size and in location indicated in water main.
- B. Water-Main Connection: Tap water main according to requirements of water utility company and of size and in location indicated.
- C. Make connections larger than NPS 2 with tapping machine according to the following:
 - 1. Install tapping sleeve and tapping valve according to MSS SP-60.
 - 2. Install tapping sleeve on pipe to be tapped. Position flanged outlet for gate valve.
 - 3. Use tapping machine compatible with valve and tapping sleeve; cut hole in main. Remove tapping machine and connect water-service piping.

4. Install gate valve onto tapping sleeve. Comply with MSS SP-60. Install valve with stem pointing up and with valve box.
 - D. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.
 1. Install PE corrosion-protection encasement according to ASTM A 674 or AWWA C105.
 - E. Bury piping with depth of cover over top at least 60 inches, with top at least 12 inches below level of maximum frost penetration.
 - F. Install piping by tunneling or jacking, or combination of both, under streets and other obstructions that cannot be disturbed.
 - G. Extend water-service piping and connect to water-supply source and building-water-piping systems at outside face of building wall in locations and pipe sizes indicated.
 1. Terminate water-service piping at building wall until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building-water-piping systems when those systems are installed.
 - H. Sleeves are specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."
 - I. Mechanical sleeve seals are specified in Section 22 05 17 "Sleeves and Sleeve Seals for Plumbing Piping."
 - J. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.
 - K. See Section 22 11 16 "Domestic Water Piping" for potable-water piping inside the building.
- 3.6 JOINT CONSTRUCTION
- A. See Section 33 05 00 "Common Work Results for Utilities" for basic piping joint construction.
 - B. Make pipe joints according to the following:

1. Copper-Tubing, Pressure-Sealed Joints: Use proprietary crimping tool and procedure recommended by copper, pressure-seal-fitting manufacturer.
2. Ductile-Iron Piping, Gasketed Joints for Water-Service Piping: AWWA C600 and AWWA M41.
3. Ductile-Iron Piping, Gasketed Joints for Fire-Service-Main Piping: UL 194.
4. Ductile-Iron Piping, Grooved Joints: Cut-groove pipe. Assemble joints with grooved-end, ductile-iron-piping couplings, gaskets, lubricant, and bolts according to coupling manufacturer's written instructions.
5. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
 - a. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric [flanges] [flange kits] [nipples].
 - b. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.7 ANCHORAGE INSTALLATION

- A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:
 1. Concrete thrust blocks.
 2. Locking mechanical joints.
 3. Set-screw mechanical retainer glands.
 4. Bolted flanged joints.
 5. Heat-fused joints.
 6. Pipe clamps and tie rods.
- B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches. Include anchorages for the following piping systems:
 1. Gasketed-Joint, Ductile-Iron, Water-Service Piping: According to AWWA C600.
 2. Gasketed-Joint, PVC Water-Service Piping: According to AWWA M23.

3. Bonded-Joint Fiberglass, Water-Service Piping: According to AWWA M45.
4. Fire-Service-Main Piping: According to NFPA 24.
- C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.8 VALVE INSTALLATION

- A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.
- B. AWWA Valves Other Than Gate Valves: Comply with AWWA C600 and AWWA M44.
- C. UL/FMG, Gate Valves: Comply with NFPA 24. Install each underground valve and valves in vaults with stem pointing up and with vertical cast-iron indicator post.
- D. UL/FMG, Valves Other Than Gate Valves: Comply with NFPA 24.
- E. MSS Valves: Install as component of connected piping system.
- F. Corporation Valves and Curb Valves: Install each underground curb valve with head pointed up and with service box.
- G. Relief Valves: Comply with AWWA C512. Install aboveground with shutoff valve on inlet.

3.9 CONNECTIONS

- A. See Section 33 05 00 "Common Work Results for Utilities" for piping connections to valves and equipment.
- B. Connect water-distribution piping to existing water main. Use tapping sleeve and tapping valve.
- C. Connect water-distribution piping to interior [domestic water] [and] [fire-suppression] piping.
- D. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

- E. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.10 FIELD QUALITY CONTROL

- A. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.
- B. Hydrostatic Tests: Test at not less than one-and-one-half times working pressure for two hours.
 - 1. Increase pressure in 50-psig increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig. Slowly increase again to test pressure and hold for 1 more hour. Maximum allowable leakage is 2 quarts per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.
- C. Prepare reports of testing activities.

3.11 IDENTIFICATION

- A. Install continuous underground detectable warning tape during backfilling of trench for underground water-distribution piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in Section 31 20 00 "Earth Moving."
- B. Permanently attach equipment nameplate or marker indicating plastic water-service piping, on main electrical meter panel. See Section 33 05 00 "Common Work Results for Utilities" for identifying devices.

3.12 CLEANING

- A. Clean and disinfect water-distribution piping as follows:
 - 1. Purge new water-distribution piping systems and parts of existing systems that have been altered, extended, or repaired before use.
 - 2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in NFPA 24 for flushing of piping. Flush piping system with clean, potable water until dirty water does not appear at points of outlet.

3. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:
 - a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow to stand for 24 hours.
 - b. Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow to stand for 3 hours.
 - c. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
 - d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.
- B. Prepare reports of purging and disinfecting activities.

END OF SECTION

SECTION 22 11 16

DOMESTIC WATER PIPING

(Part of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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.

- B. Related Section:

- 1. Division 22 Section "Facility Water Distribution Piping" for water-service piping outside the building from source to the point where water-service piping enters the building.

1.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Domestic water piping and support and installation shall withstand effects of earthquake motions determined according to ASCE/SEI 7.

1.4 SUBMITTALS

- A. Product Data: Transition Fittings and Dielectric Fittings.

- B. Water Samples: Specified in "Cleaning" Article.
- C. Coordination Drawings: For piping in equipment rooms and other congested areas, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
 - 1. Fire-suppression-water piping.
 - 2. Domestic water piping.
 - 3. Compressed air piping.
 - 4. HVAC hydronic piping.
- D. Field quality-control reports.
- E. Grooved joint couplings and fittings shall be shown on drawings and product submittals, and be specifically identified with the applicable Victaulic or Engineer-Approved equal style or series number

1.5 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Pressure-Seal Joining Procedure for Copper Tubing: Qualify operators according to training provided by Viega; Plumbing and Heating Systems.
 - 2. Pressure-Seal Joining Procedure for Steel Piping. Qualify operators according to training provided by Victaulic Company
- B. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- C. Comply with NSF 14 for plastic, potable domestic water piping and components.
- D. Comply with NSF 61 for potable domestic water piping and components.
- E. To assure uniformity and compatibility of piping components in grooved end piping systems, all grooved products utilized shall be supplied by Victaulic or an Engineer Approved Equal. Grooving tools shall be supplied by the same manufacturer as the grooved components

1.6 PROJECT CONDITIONS

- A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of water service.
2. Do not proceed with interruption of water service without Owner's written permission.

1.7 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

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. Plastic piping components shall be marked with "NSF-pw."

2.2 COPPER TUBE AND FITTINGS

- A. Hard Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) water tube, drawn temper.
- B. Soft Copper Tube: ASTM B 88, Type K (ASTM B 88M, Type A) 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.
 5. Not required on grooved installations. The coupling shall act as the union
- G. Appurtenances for Grooved-End Copper Tubing:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Victaulic Company.
 - b. Anvil International
 - c. Shurjoint Piping Products
 - d. Engineer Approved Equal
 2. Bronze Fittings for Grooved-End, Copper Tubing: ASTM B 75 (ASTM B 75M) copper tube or ASTM B 584 bronze castings.
 3. Mechanical Couplings for Grooved-End Copper Tubing Sizes 2"-8":
 - a. Copper-tube dimensions and design similar to AWWA C606.
 - b. Ferrous housing sections cast with offsetting, angle-pattern bolt pads to provide system rigidity upon visual confirmation of metal-to-metal bolt pad contact with no torque requirement,.
 - c. Grade P Fluoroelastomer blend gaskets suitable for hot and cold water.
 - d. Bolts and nuts.
 - e. Minimum Pressure Rating: 300 psig
 - f. Victaulic Style 607
 4. Mechanical T: Victaulic Style 622
 5. Grooved-End-Tube Flange Adapters: Copper-tube dimensions and design similar to AWWA C606. Ductile-iron casting, coated with copper-colored enamel, flat-faced, for engaging into roll grooved copper tube and fittings and bolting directly to flanges with ANSI Class 125 and 150 bolt hole patterns. Victaulic Style 641
- H. Press-Type Fittings, NPS 2-1/2 to NPS 4: Bronze fitting with stainless-steel grip ring and EPDM O-ring seal in each end.
- a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - b. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Viega; Plumbing and Heating Systems.

- I. Transition Couplings for Metal Piping: Metal coupling or other manufactured fitting same size as, with pressure rating at least equal to and ends compatible with, piping to be joined

2.3 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe:

1. AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Standard-Pattern, Mechanical-Joint Fittings:

1. AWWA C110/A21.10, ductile or gray iron.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

C. Compact-Pattern, Mechanical-Joint Fittings:

1. AWWA C153/A21.53, ductile iron.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

D. Push-on-Joint, Ductile-Iron Pipe:

1. AWWA C151/A21.51.
2. Push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.

E. Standard-Pattern, Push-on-Joint Fittings:

1. AWWA C110/A21.10, ductile or gray iron.
2. Gaskets: AWWA C111/A21.11, rubber.

F. Compact-Pattern, Push-on-Joint Fittings:

1. AWWA C153/A21.53, ductile iron.
2. Gaskets: AWWA C111/A21.11, rubber.

- G. Plain-End, Ductile-Iron Pipe: AWWA C151/A21.51.
- H. Appurtenances for Grooved-End, Ductile-Iron Pipe:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Victaulic Company.
 - b. Shutjoint Piping Products.
 - c. Smith-Cooper International.
 - d. Engineer Approved Equal
 - 2. Fittings for Grooved-End, Ductile-Iron Pipe: ASTM A 536, ductile-iron castings with dimensions that match pipe and rigid radius cut grooved ends.
 - 3. Mechanical Couplings for Grooved-End, Ductile-Iron-Piping:
 - a. AWWA C606 for ductile-iron-pipe dimensions.
 - b. Ferrous housing sections.
 - c. EPDM-rubber gaskets of a flush seal design suitable for hot and cold water.
 - d. Bolts and nuts.
 - e. Minimum Pressure Rating:
 - 1) NPS 14 to NPS 18: 250 psig

2.4 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.

2.5 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.

C. Sleeve-Type Transition Coupling: AWWA C219.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cascade Waterworks Manufacturing.
 - b. Dresser, Inc.; Piping Specialties Products.
 - c. Ford Meter Box Company, Inc. (The).
 - d. JCM Industries.
 - e. Romac Industries, Inc.
 - f. Smith-Blair, Inc.; a Sensus company.
 - g. Viking Johnson.

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. Capitol Manufacturing Company; member of the Phoenix Forge Group.
 - b. Central Plastics Company.
 - c. Hart Industries International, Inc.
 - d. Jomar International.

- e. Matco-Norca.
 - f. McDonald, A. Y. Mfg. Co.
 - g. Watts; a division of Watts Water Technologies, Inc.
 - h. Wilkins; a Zurn company.
- 2. Standard: ASSE 1079.
 - 3. Pressure Rating: 150 psig minimum at 180 deg F.
 - 4. 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; member of the Phoenix Forge Group.
 - b. Central Plastics Company.
 - c. Matco-Norca.
 - d. Watts; a division of Watts Water Technologies, Inc.
 - e. Wilkins; a Zurn company.
 - 2. Standard: ASSE 1079.
 - 3. Factory-fabricated, bolted, companion-flange assembly.
 - 4. Pressure Rating: 150 psig minimum at 180 deg F.
 - 5. 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. Nonconducting materials for field assembly of companion flanges.
3. Pressure Rating: 150 psig
4. Gasket: Neoprene or phenolic.
5. Bolt Sleeves: Phenolic or polyethylene.
6. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
 - a. Precision Plumbing Products, Inc.
 - b. Victaulic Company.
 - c. Matco-Norca.
2. Standard: IAPMO PS 66.
3. Electroplated steel nipple complying with ASTM F 1545 or silicon lead free.
4. Pressure Rating and Temperature: 300 psig at 225 deg F.
5. End Connections: Male threaded or grooved.
6. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Comply with requirements in Division 31 Section "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 ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

- D. Install any underground copper tube and ductile-iron pipe in PE encasement according to ASTM A 674 or AWWA C105/A21.5.
- E. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Division 22 Section "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Division 22 Section "Domestic Water Piping Specialties."
- F. Install shutoff valve immediately upstream of each dielectric fitting.
- G. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Division 22 Section "Domestic Water Piping Specialties."
- H. Install domestic water piping and plumb.
- I. Rough-in domestic water piping for water-meter installation according to utility company's requirements.
- J. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- K. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- L. 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.
- M. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
- N. Install piping to permit valve servicing.
- O. Install nipples, unions, special fittings, grooved joint couplings and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.
- P. Install piping free of sags and bends.
- Q. Install fittings for changes in direction and branch connections. On grooved installations, mechanical T's may be used in lieu of fittings.
- R. Install unions or grooved joint couplings in copper tubing at final connection to each piece of equipment, machine, and specialty.
- S. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Division 22 Section "Meters and Gages for Plumbing Piping."
- T. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Division 22 Section "Domestic Water Pumps."

- U. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Division 22 Section "Meters and Gages for Plumbing Piping."
- V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."
- W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."
- X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.3 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 pipes, tubes, and fittings before assembly.
- C. 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.
- D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Braze Joints" chapter.
- E. 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."
- F. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.
- G. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.
- 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. Grooved joint piping systems shall be installed in accordance with the manufacturer's guidelines and

recommendations. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be developed and supplied by the system manufacturer. Grooved end shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove. A factory trained field representative shall provide on-site training to contractor's field personnel in the installation of grooved piping products. Factory trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products

- 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. Grooved joint piping systems shall be installed in accordance with the manufacturer's guidelines and recommendations. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be developed and supplied by the system manufacturer. Grooved end shall be clean and free from indentations, projections in the area from pipe end to groove. A factory trained field representative shall provide on-site training to contractor's field personnel in the installation of grooved piping products. Factory trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.
- J. Joint Construction for Grooved-End Steel Piping: Make joints according to AWWA C606. Roll groove ends of pipe as specified. 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. Grooved joint piping systems shall be installed in accordance with the manufacturer's guidelines and recommendations. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be developed and supplied by the system manufacturer. Grooved end shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove. A factory trained field representative shall provide on-site training to contractor's field personnel in the installation of grooved piping products. Factory trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.
- K. 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.
- L. 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 2 and Smaller: Use dielectric unions.
- C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flange kits.
- D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for seismic-restraint devices in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- B. Comply with requirements for pipe hanger, support products, and installation in Division 22 Section "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 (30 m) 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. Support vertical piping and tubing at base and at each floor.

- D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch (10 mm).
- E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/2 and Smaller: 60 inches with 3/8-inch rod.
 - 2. NPS 2 to NPS 4: 10 feet with 3/8 inch rod.
 - 3. NPS 5 to NPS 8: 10 feet with 1/2-inch rod.
- F. Install supports for vertical copper tubing every 10 feet.
- G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 3/4 and Smaller: 10 feet with 3/8-inch rod.
 - 2. NPS 1 to NPS 4: 12 feet with 3/8-inch rod.
 - 3. NPS 5 to NPS 8: 12 feet with 1/2-inch rod.
 - 4. NPS 10 and larger: 12 feet with 5/8-inch rod.
- H. Install supports for vertical steel piping every 15 feet.
- I. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 3/4 and Smaller: 10 feet with 3/8-inch rod.
 - 2. NPS 1 to NPS 4: 12 feet with 3/8-inch rod.
 - 3. NPS 5 to NPS 8: 12 feet with 1/2-inch rod.
 - 4. NPS 10 and larger: 12 feet with 5/8-inch rod.
- J. Install supports for vertical steel piping every 15 feet.
- K. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.
- L. Copper Piping: Victaulic Style 607 rigid couplings may be used on copper piping systems, which meet the support and hanging requirements of ASME B31.9.

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. Comply with requirements for connection sizes in Division 22 plumbing fixture Sections.
 - 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 Division 22 Section "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.
- 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.
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 (50 mg/L) 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 (200 mg/L) 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. Clean non-potable domestic water piping as follows:

DOMESTIC WATER PIPING

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
- C. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.
- D. 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, Victaulic grooved joint couplings and unions may be used for aboveground piping joints unless otherwise indicated.
- C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.
- D. Under-building-slab, domestic water, building-service piping, NPS 3 and smaller, shall be the following:
 1. Soft copper tube, ASTM B 88, Type K (ASTM B 88M, Type A); wrought-copper, solder-joint fittings; and brazed joints.
- E. Under-building-slab, domestic water, building-service piping, NPS 4 and larger, shall be one of the following:
 1. Soft copper tube, ASTM B 88, Type K (ASTM B 88M, Type A); wrought-copper, solder-joint fittings; and brazed joints.
 2. Mechanical-joint, ductile-iron pipe; standard-pattern, mechanical-joint fittings; and mechanical joints.
 3. Push-on-joint, ductile-iron pipe; standard-pattern, push-on-joint fittings; and gasketed joints.
 4. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.

- F. Under-building-slab, combined domestic water, building-service, and fire-service-main piping, NPS 6 to NPS 12, shall be one of the following:
 - 1. Mechanical-joint, ductile-iron pipe; standard-pattern, mechanical-joint fittings; and mechanical joints.
 - 2. Push-on-joint, ductile-iron pipe; standard-pattern, push-on-joint fittings; and gasketed joints.
 - 3. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.
- G. Under-building-slab, domestic water piping, NPS 2 and smaller, shall be the following:
 - 1. Hard or soft copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); wrought-copper, solder-joint fittings; and brazed joints.
- H. Aboveground domestic water piping, NPS 2 and smaller, shall be one of the following:
 - 1. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); wrought copper, solder-joint fittings; and soldered joints or press fittings.
- I. Aboveground domestic water piping, NPS 2-1/2 to NPS 6 shall be one of the following:
 - 1. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); cast or wrought-copper, solder-joint fittings; and brazed joints or press fittings up to 4".
 - 2. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); grooved-joint, copper-tube appurtenances; and grooved 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 or gate 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. Throttling Duty: Use ball valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
 3. Hot-Water Circulation Piping, Balancing Duty: Calibrated Memory-stop balancing valves.
 4. Drain Duty: Hose-end drain valves.
- B. Use check valves to maintain correct direction of domestic water flow to and from equipment.
- C. Iron grooved-end valves may be used with grooved-end piping.

END OF SECTION

SECTION 22 11 19

DOMESTIC WATER PIPING SPECIALTIES

(Part of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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. Vacuum breakers.
- 2. Backflow preventers.
- 3. Water pressure-reducing valves.
- 4. Balancing valves.
- 5. Temperature-actuated, water mixing valves.
- 6. Strainers.
- 7. Outlet boxes.
- 8. Hose bibbs.
- 9. Wall hydrants.
- 10. Roof hydrants.

11. Drain valves.
12. Water-hammer arresters.
13. Air vents.
14. Electronic Trap-seal primer systems.
15. Specialty valves.

B. Related Requirements:

1. Section 22 05 19 "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
2. Section 22 11 16 "Domestic Water Piping" for water meters.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For domestic water piping specialties.
 1. Include 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 domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

- A. Potable-water piping and components shall comply with NSF 61 and NSF 14 and shall be lead-free.

2.2 PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

2.3 VACUUM BREAKERS

- A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. FEBCO; a division of Watts Water Technologies, Inc.
 - c. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - d. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
 - 2. Standard: ASSE 1001.
 - 3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
 - 4. Body: Bronze.
 - 5. Inlet and Outlet Connections: Threaded.
 - 6. Finish: Chrome plated.
- B. Hose-Connection Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. MIFAB, Inc.
 - b. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - c. Woodford Manufacturing Company; a division of WCM Industries, Inc.
 - d. Zurn Industries, LLC; Plumbing Products Group; Light Commercial Products.
 - e. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
 2. Standard: ASSE 1011.
 3. Body: Bronze, nonremovable, with manual drain.
 4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
 5. Finish: Chrome or nickel plated.
- C. Pressure Vacuum Breakers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Fire & Waterworks; a division of Watts Water Technologies, Inc.
 - b. Conbraco Industries, Inc.
 - c. FEBCO; a division of Watts Water Technologies, Inc.
 - d. Flomatic Corporation.
 - e. Toro Company (The); Irrigation Div.
 - f. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - g. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
 2. Standard: ASSE 1020.
 3. Operation: Continuous-pressure applications.

4. Pressure Loss: 5 psig maximum, through middle third of flow range.
5. Accessories:
 - a. Valves: Ball type, on inlet and outlet.

2.4 BACKFLOW PREVENTERS

A. Intermediate Atmospheric-Vent Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. FEBCO; a division of Watts Water Technologies, Inc.
 - b. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - c. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Standard: ASSE 1012.
3. Operation: Continuous-pressure applications.
4. Body: Bronze.
5. End Connections: Solder joint.
6. Finish: Chrome plated.

B. Reduced-Pressure-Principle Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. FEBCO; a division of Watts Water Technologies, Inc.
 - c. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - d. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.

2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 10 psig maximum, through middle third of flow range.
5. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
7. Configuration: Designed for horizontal, straight-through flow.
8. Accessories:
 - a. Valves NPS 2 and Smaller: Ball type with threaded ends on inlet and outlet.
 - b. Valves NPS 2-1/2 and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
 - c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

C. Beverage-Dispensing-Equipment Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - c. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Standard: ASSE 1022.
3. Operation: Continuous-pressure applications.
4. Size: NPS 1/4 or NPS 3/8.
5. Body: Stainless steel.

6. End Connections: Threaded.

D. Dual-Check-Valve Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cash Acme; a division of Reliance Worldwide Corporation.
 - b. Conbraco Industries, Inc.
 - c. FEBCO; a division of Watts Water Technologies, Inc.
 - d. Flomatic Corporation.
 - e. Ford Meter Box Company, Inc. (The).
 - f. Honeywell International Inc.
 - g. Legend Valve.
 - h. McDonald, A. Y. Mfg. Co.
 - i. Mueller Co. Ltd.; a subsidiary of Mueller Water Products Inc.
 - j. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - k. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Standard: ASSE 1024.
3. Operation: Continuous-pressure applications.
4. Body: Bronze with union inlet.

E. Hose-Connection Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - c. Woodford Manufacturing Company; a division of WCM Industries, Inc.

2. Standard: ASSE 1052.
3. Operation: Up to 10-foot head of water back pressure.
4. Inlet Size: NPS 1/2 or NPS 3/4
5. Outlet Size: Garden-hose thread complying with ASME B1.20.7.
6. Capacity: At least 3-gpm flow.

F. Backflow-Preventer Test Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. FEBCO; a division of Watts Water Technologies, Inc.
 - c. Flomatic Corporation.
 - d. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - e. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.5 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:

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. Cash Acme; a division of Reliance Worldwide Corporation.
 - b. Conbraco Industries, Inc.
 - c. Honeywell International Inc.
 - d. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.

- e. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
 - 2. Standard: ASSE 1003.
 - 3. Pressure Rating: Initial working pressure of 150 psig
 - 4. Body: Bronze with chrome-plated finish for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3
 - 5. Valves for Booster Heater Water Supply: Include integral bypass.
 - 6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3
- B. Water-Control Valves:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CLA-VAL.
 - b. Flomatic Corporation.
 - c. OCV Control Valves.
 - d. Victaulic/Bermad
 - 1) Victaulic PRV Station: Factory assembled pressure reducing valve (PRV) Station, Style 386 A-E, may be utilized in accordance with the requirements of the specification.
 - e. Watts; a division of Watts Water Technologies, Inc.; Control Valves (Watts ACV).
 - f. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
 - 2. Description: Pilot-operated, diaphragm-type, single-seated, main water-control valve.
 - 3. Pressure Rating: Initial working pressure of 150 psig minimum with AWWA C550 or FDA-approved, interior epoxy coating. Include small pilot-control valve, restrictor device, specialty fittings, and sensor piping.

4. Main Valve Body: Cast- or ductile-iron body with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body.
 - a. Size: 4" NPS.
 - b. Pattern: Globe-valve design.
 - c. Trim: Stainless steel.
5. Design Flow: <255 gpm >.
6. Design Inlet Pressure: <38 psig >.
7. Design Outlet Pressure Setting: <24 psig >.
8. End Connections: flanged or grooved for NPS 2-1/2 and larger

2.6 BALANCING VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. ThermOmegaTech, Inc.
 2. Victaulic
 3. Watts
 4. Or approved equal
- B. Product:
 1. Furnish and install CircuitSolver® as indicated on the plans. CircuitSolver® shall be self-contained and fully automatic without additional piping or control mechanisms. Valve shall be a CircuitSolver® as manufactured by ThermOmegaTech®, Inc. CircuitSolver® shall regulate the flow of recirculated domestic hot water based on water temperature entering the valve regardless of system operating pressure. As the water temperature increases the valve proportionally closes dynamically adjusting flow to meet the specified temperature.

2. CircuitSolver® body and all internal components shall be constructed of stainless steel with major components constructed of type 303 stainless steel. CircuitSolver® shall be rated to 200 PSIG maximum working pressure and 250°F (121°C) maximum working temperature. The thermal actuator inside the valve shall be spring loaded and self cleaning, delivering closing thrust sufficient to keep orifice opening free of scale deposits. All CircuitSolver® valve are NSF-61 certified for use in all domestic water systems. Installation of CircuitSolver® valve shall be made by qualified tradesmen in each domestic hot water return piping branch beyond last hot water device in that branch. Refer to the submittals above for additional specs.

2.7 TEMPERATURE-ACTUATED, WATER MIXING VALVES

A. Water-Temperature Limiting Devices:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong International, Inc.
 - b. Cash Acme; a division of Reliance Worldwide Corporation.
 - c. Conbraco Industries, Inc.
 - d. Honeywell International Inc.
 - e. Legend Valve.
 - f. Leonard Valve Company.
 - g. Powers; a division of Watts Water Technologies, Inc.
 - h. Symmons Industries, Inc.
 - i. TACO Incorporated.
 - j. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - k. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.
2. Standard: ASSE 1017.

3. Pressure Rating: 125 psig (860 kPa).
 4. Type: Thermostatically controlled, water mixing valve.
 5. Material: Bronze body with corrosion-resistant interior components.
 6. Connections: Threaded union inlets and outlet.
 7. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
 8. Valve Finish: Chrome plate.
- B. Primary, Thermostatic, Water Mixing Valves:
1. Standard: ASSE 1017 valves.
 2. Basis of design: Manufacturers: Subject to compliance with requirements above, provide products by one of the following:
 - a. Leonard Valve Company.
 - b. Lawler Manufacturing Company, Inc.
 - c. Powers; a division of Watts Water Technologies, Inc.
- C. Individual-Fixture, Water Tempering Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cash Acme; a division of Reliance Worldwide Corporation.
 - b. Conbraco Industries, Inc.
 - c. Honeywell International Inc.
 - d. Lawler Manufacturing Company, Inc.
 - e. Leonard Valve Company.
 - f. Powers; a division of Watts Water Technologies, Inc.
 - g. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
 - h. Zurn Industries, LLC; Plumbing Products Group; Wilkins Water Control Products.

2. Standard: ASSE 1016, thermostatically controlled, water tempering valve.
3. Pressure Rating: 125 psig minimum unless otherwise indicated.
4. Body: Bronze body with corrosion-resistant interior components.
5. Temperature Control: Adjustable.
6. Inlets and Outlet: Threaded.
7. Provide check stops on hot and cold supply to each mixing valve as Watts LFCS or similar.
8. Finish: Rough or chrome-plated bronze.

D. Primary Water Tempering Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following::
 - a. Heat-Timer Corporation.
 - b. Holby Valve Co., Inc.
 - c. Symmons Industries, Inc.
2. Standard: ASSE 1017, thermostatically controlled, water tempering valve, listed as tempering valve.
3. Pressure Rating: 125 psig minimum unless otherwise indicated.
4. Body: Bronze.
5. Temperature Control: Manual.
6. Inlets and Outlet: Threaded.
7. Valve Finish: Rough bronze.

2.8 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 or grooved 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 5 and Larger: 0.10 inch
6. Drain: Factory-installed, hose-end drain valve.

2.9 OUTLET BOXES

A. Laundry Outlet Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Acorn Engineering Company.
 - b. IPS Corporation.
 - c. LSP Products Group, Inc.
 - d. Oatey.
 - e. Plastic Oddities.
2. Mounting: Recessed.
3. Material and Finish: Stainless-steel box and faceplate.
4. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.
5. Supply Shutoff Fitting: NPS 1/2 gate, globe, or ball valve and NPS 1/2 copper, water tubing.

2.10 HOSE STATIONS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ARCHON Industries, Inc.
 - 2. Armstrong International, Inc.
 - 3. Cooney Brothers, Inc.
 - 4. DynaFluid Ltd.
 - 5. Leonard Valve Company.
 - 6. Strahman Valves, Inc.
 - 7. T & S Brass.
- B. Single-Temperature-Water Hose Stations:
 - 1. Standard: ASME A112.18.1.
 - 2. Cabinet: Stainless-steel enclosure with exposed valve handle, hose connection, and hose rack. Include thermometer in front.
 - 3. Hose-Rack Material: Stainless steel.
 - 4. Body Material: Bronze with stainless-steel wetted parts.
 - 5. Body Finish: Rough bronze, chrome plated.
 - 6. Mounting: Wall, with reinforcement.
 - 7. Supply Fittings: NPS 3/4 gate, globe, or ball valve and check valve and NPS 3/4 copper, water tubing. Omit check valve if check stop is included with fitting.
 - 8. Hose: Manufacturer's standard, for service fluid, temperature, and pressure; 50 feet long.
 - 9. Nozzle: With hand-squeeze, on-off control.

10. Vacuum Breaker:

- a. Integral or factory-installed, nonremovable, manual-drain-type, hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
- b. Garden-hose thread complying with ASME B1.20.7 on outlet.

2.11 HOSE BIBBS

A. Hose Bibbs:

1. Standard: ASME A112.18.1 for sediment faucets.
2. Body Material: Bronze.
3. Seat: Bronze, replaceable.
4. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 psig
7. Vacuum Breaker: Integral, non-removable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Service Areas: Rough bronze.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
12. Operation for Service Areas: Wheel handle.
13. Operation for Finished Rooms: Operating key.
14. Include operating key with each operating-key hose bibb.
15. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.12 WALL HYDRANTS

A. Non-freeze Wall Hydrants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. Prier Products, Inc.
 - d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - e. Tyler Pipe; Wade Div.
 - f. Watts Drainage Products.
 - g. Woodford Manufacturing Company; a division of WCM Industries, Inc.
 - h. Zurn Industries, LLC; Plumbing Products Group; Light Commercial Products.
 - i. Zurn Industries, LLC; Plumbing Products Group; Specification Drainage Products.
2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 or NPS 1
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounted with cover.
9. Box and Cover Finish: Polished nickel bronze.
10. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.

11. Nozzle and Wall-Plate Finish: Polished nickel bronze.

12. Operating Keys(s): Two with each wall hydrant.

2.13 ROOF HYDRANTS

A. Non-freeze, Draining type post Wall Hydrants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Freeze Flow.
 - b. Watts Drainage Products.
 - c. Woodford Manufacturing Company; a division of WCM Industries, Inc.
 - d. Or approved equal.
2. Standard: ASME A112.21.3M
3. Type: Nonfreeze, exposed outlet post hydrant
4. Operation: Loose key.
5. Casing and Operating Rod: Of at least length required to match roof thickness.
6. Inlet: NPS 3/4
7. Outlet: Garden hose thread complying with ASME B1.20.7.

2.14 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. 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.

2.15 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMTROL, Inc.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. Precision Plumbing Products, Inc.
 - e. Sioux Chief Manufacturing Company, Inc.
 - f. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - g. Tyler Pipe; Wade Div.
 - h. Watts Drainage Products.

- i. Zurn Industries, LLC; Plumbing Products Group; Specification Drainage Products.
2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.16 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.

2.17 ELECTRONIC TRAP-SEAL PRIMER DEVICE

A. Supply-Type, Trap-Seal Primer Device:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. MIFAB, Inc.
 - b. Precision Plumbing Products, Inc.
 - c. Sioux Chief Manufacturing Company, Inc.
 - d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - e. Watts; a division of Watts Water Technologies, Inc.; Watts Regulator Company.
2. Standard: ASSE 1044.
3. Piping: NPS 1/2, ASTM B 88, Type L; copper, water tubing
4. Cabinet: Recess mounted steel box with stainless-steel cover.
5. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120-V ac power.
 - 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.
6. Vacuum Breaker: ASSE 1001.
7. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
8. Number of outlets: Up to four

2.18 SPECIALTY VALVES

- ### A. Comply with requirements for general-duty metal valves in Section 22 05 23 "General-Duty Valves for Plumbing Piping."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. 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.
- B. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.
- C. Install water-control valves with inlet and outlet shutoff valves and bypass valve. Install pressure gages on inlet and outlet.
- D. Install balancing valves in locations where they can easily be adjusted.
- E. Install temperature-actuated, water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
 - 1. Install cabinet-type units recessed in or surface mounted on wall as specified.
- F. Install Y-pattern strainers for water on supply side of each control valve water pressure-reducing valve, solenoid valve.
- G. 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. Comply with requirements for fire-retardant-treated-wood blocking in Section 06 10 00 "Rough Carpentry."
- H. Install hose stations with check stops or shutoff valves on inlets and with thermometer on outlet.

1. Install cabinet-type units recessed in or surface mounted on wall as specified. Install 2-by-4-inch fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking in Section 06 10 00 "Rough Carpentry."
 - I. Install ground hydrants with 1 cu. yd. of crushed gravel around drain hole. Set ground hydrants with box flush with grade.
 - J. Install draining-type post hydrants with 1 cu. yd. of crushed gravel around drain hole. Set post hydrants in concrete paving or in 1 cu. ft. of concrete block at grade.
 - K. Set non-freeze, nondraining-type post hydrants in concrete or pavement.
 - L. Set freeze-resistant yard hydrants with riser pipe in concrete or pavement. Do not encase canister in concrete.
 - 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 discharge onto floor drain.
 - 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.
 - P. Install drainage-type, trap-seal primer valves as lavatory trap with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting.
 - Q. Install trap-seal primer systems with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.
 - R. Install drain valves at all low points in the water piping system and at the base of each riser.
- 3.2 CONNECTIONS
- A. Comply with requirements for ground equipment in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

- B. Fire-retardant-treated-wood blocking is specified in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" for electrical connections.

3.3 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
 - 1. Pressure vacuum breakers.
 - 2. Intermediate atmospheric-vent backflow preventers.
 - 3. Reduced-pressure-principle backflow preventers.
 - 4. Double-check, backflow-prevention assemblies.
 - 5. Carbonated-beverage-machine backflow preventers.
 - 6. Dual-check-valve backflow preventers.
 - 7. Reduced-pressure-detector, fire-protection, backflow-preventer assemblies.
 - 8. Double-check, detector-assembly backflow preventers.
 - 9. Water pressure-reducing valves.
 - 10. Calibrated balancing valves.
 - 11. Primary, thermostatic, water mixing valves.
 - 12. Manifold, thermostatic, water mixing-valve assemblies.
 - 13. Photographic-process, thermostatic, water mixing-valve assemblies.
 - 14. Primary water tempering valves.
 - 15. Outlet boxes.
 - 16. Hose stations.
 - 17. Supply-type, trap-seal primer valves.

18. Trap-seal primer systems.

- B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Test each pressure vacuum breaker, reduced-pressure-principle backflow preventer, double-check, backflow-prevention assembly and balancing of the hot water recirculation system 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. Set field-adjustable pressure set points of water pressure-reducing valves.
- B. Set field-adjustable flow set points of balancing valves.
- C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

END OF SECTION

SECTION 22 11 23

DOMESTIC WATER PUMPS

(Part of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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. In-line, sealless centrifugal pumps.
 - 2. Horizontally mounted, in-line, close-coupled centrifugal pumps.
 - 3. Vertically mounted, in-line, close-coupled centrifugal pumps.

1.3 DEFINITIONS

- A. 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.

1.4 ACTION SUBMITTALS

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

1.5 CLOSEOUT SUBMITTALS

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

1.6 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. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.7 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 rigging instructions for handling.

1.8 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 IN-LINE, SEALLESS CENTRIFUGAL PUMPS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Taco pumps or comparable product by one of the following:
 - 1. Armstrong Pumps Inc.
 - 2. Bell & Gossett Domestic Pump; ITT Corporation.
 - 3. Grundfos Pumps Corp.

4. WILO USA LLC - WILO Canada Inc.

B. Description: Factory-assembled and -tested, in-line, close-coupled, canned-motor, sealless, overhung-impeller centrifugal pumps.

C. Pump Construction:

1. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge type with motor and impeller on common shaft and designed for installation with pump and motor shaft horizontal.

2. Casing: Bronze, with threaded or companion-flange connections.

3. Impeller: Plastic.

4. Motor: Single speed, unless otherwise indicated.

2.2 HORIZONTALLY MOUNTED, IN-LINE, CLOSE-COUPLED CENTRIFUGAL PUMPS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Taco Pumps or comparable product by one of the following:

1. Alyan Pump Co.

2. Armstrong Pumps Inc.

3. Bell & Gossett Domestic Pump; ITT Corporation.

4. Marshall Engineered Products Co.

5. PACO Pumps; Grundfos Pumps Corporation, U.S.A.

6. Pentair Pump Group; Aurora Pump.

7. Thrush Company, Inc.

B. Description: Factory-assembled and -tested, in-line, single-stage, close-coupled, overhung-impeller centrifugal pumps designed for installation with pump and motor shaft mounted horizontal.

C. Pump Construction:

1. Casing: Radially split with 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: Statically and dynamically balanced, closed, and keyed to shaft.
 3. Shaft and Shaft Sleeve: Steel shaft with deflector, with copper-alloy shaft sleeve. Include water slinger on shaft between motor and seal.
 4. Seal: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and rubber bellows and gasket.
 5. Bearings: Oil-lubricated; bronze-journal or ball type.
 6. Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
- D. Motor: Single speed, with grease-lubricated ball bearings; and resiliently or rigidly mounted to pump casing.
- E. Capacities and Characteristics:
1. As shown on the schedule

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

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Taco Pumps or comparable product by one of the following:
1. Alyan Pump Co.
 2. Armstrong Pumps Inc.
 3. Bell & Gossett Domestic Pump; ITT Corporation.
 4. Federal Pump Corp.
 5. Flo Fab inc.
 6. Grundfos Pumps Corp.
 7. Marshall Engineered Products Co.

8. PACO Pumps; Grundfos Pumps Corporation, U.S.A.

9. Peerless Pump, Inc.

10. Pentair Pump Group; Aurora Pump.

11. Thrush Co. Inc.

12. Weinman Division; Crane Pumps & Systems.

B. 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.

C. Pump Construction:

1. Casing: Radially split, cast iron, 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. Include pump manufacturer's base attachment for mounting pump on concrete base.

2. Impeller: Statically and dynamically balanced, closed, and keyed to shaft.

3. Shaft and Shaft Sleeve: Stainless-steel shaft, with copper-alloy shaft sleeve.

4. 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.

5. Bearings: Oil-lubricated; bronze-journal or ball type.

6. Shaft Coupling: Flexible or rigid type if pump is provided with coupling.

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

E. Capacities and Characteristics:

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors.

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. Pressure Switches: Electric, adjustable for control of water-supply pump.
 1. Type: Water-immersion pressure sensor, for installation in piping.
 2. Enclosure: NEMA 250, Type 4X.
 3. Operation of Pump: On or off.
 4. Transformer: Provide if required.
 5. Power Requirement: [24 V, ac] [120 V, ac] <Insert power>.
- B. 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: [24 V, ac] [120 V, ac].
- C. Timers: Electric, for control of hot-water circulation pump.
 1. Type: Programmable, seven-day clock with manual override on-off switch.
 2. Enclosure: NEMA 250, Type 1, suitable for wall mounting.
 3. Operation of Pump: On or off.
 4. Transformer: Provide if required.

5. Power Requirement: [24-V ac] [120-V ac].
 6. Programmable Sequence of Operation: Up to two on-off cycles each day for seven days.
- D. Time-Delay Relays: Electric, for control of hot-water circulation pump between water heater and connected hot-water storage tank.
1. Type: Adjustable time-delay relay.
 2. Range: Up to five minutes.
 3. Setting: Five minutes.
 4. Enclosure: NEMA 250, Type 4X.
 5. Operation of Pump: On or off.
 6. Transformer: Provide if required.
 7. Power Requirement: 24-V ac, 120-V ac.
 8. Programmable Sequence of Operation: Limit pump operation to periods of burner operation plus maximum five minutes after the burner stops.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 PUMP INSTALLATION

- A. Comply with HI 1.4.
- B. Install in-line, sealless centrifugal pumps with shaft horizontal unless otherwise indicated.

- C. Install horizontally mounted, in-line, close-coupled centrifugal pumps with shaft(s) horizontal.
- D. Install vertically mounted, in-line, close-coupled centrifugal pumps with shaft vertical.
- E. Pump Mounting: Install vertically mounted, in-line, close-coupled centrifugal pumps with cast-iron base mounted on concrete base using elastomeric mounts. Comply with requirements for concrete base specified in Section 03 30 00 Cast-in-Place Concrete.
 - 1. Minimum Deflection: 1/4 inch
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the 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.
- F. Install continuous-thread hanger rods and spring hangers of size required to support pump weight.
 - 1. Comply with requirements for vibration isolation devices specified in Section 22 05 48.13 "Vibration Controls for Plumbing Piping and Equipment." Fabricate brackets or supports as required.
 - 2. Comply with requirements for hangers and supports specified in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment."
- G. Install pressure switches in water supply piping.
- H. Install thermostats in hot-water return piping.
- I. Install timers on wall in engineer's office.

- J. Install time-delay relays in piping between water heaters and hot-water storage tanks.

3.3 CONNECTIONS

- A. Comply with requirements for piping specified in Section 22 11 16 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to pumps to allow service and maintenance.
- C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.
 - 1. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:
 - a. Horizontally mounted, in-line, separately coupled centrifugal pumps.
 - b. Horizontally mounted, in-line, close-coupled centrifugal pumps.
 - c. Vertically mounted, in-line, close-coupled centrifugal pumps.
 - d. Comply with requirements for flexible connectors specified in Section 22 11 16 "Domestic Water Piping."
 - 2. 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 valves specified in Section 22 05 23 "General-Duty Valves for Plumbing Piping" and comply with requirements for strainers specified in Section 22 11 19 "Domestic Water Piping Specialties."
 - 3. Install pressure gage and snubber at suction of each pump and pressure gage and snubber at discharge of each pump. Install at integral pressure-gage tappings where provided or install pressure-gage connectors in suction and discharge piping around pumps. Comply with requirements for pressure gages and snubbers specified in Section 22 05 19 "Meters and Gages for Plumbing Piping."
- D. Connect [pressure switches,] [thermostats,] [time-delay relays,] [and] [timers] to pumps that they control.

3.4 IDENTIFICATION

- A. Comply with requirements for identification specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment" for identification of pumps.

3.5 STARTUP SERVICE

- A. 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, timers, and time-delay relays 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.

3.6 ADJUSTING

- A. Adjust 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

SECTION 22 13 13

FACILITY SANITARY SEWERS

(Part of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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 and fittings.
 - 2. Non-pressure and pressure couplings.
 - 3. Expansion joints and deflection fittings.
 - 4. Backwater valves.
 - 5. Cleanouts.
 - 6. Encasement for piping.

1.3 DEFINITIONS

- A. FRP: Fiberglass-reinforced plastic.

1.4 ACTION SUBMITTALS

- A. Product Data: For the following:

1. Expansion joints and deflection fittings.

2. Backwater valves.

B. Shop Drawings: For manholes. Include plans, elevations, sections, details, and frames and covers.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from sewer system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.

B. Profile Drawings: Show system piping in elevation. Draw profiles to horizontal scale of not less than 1 inch equals 50 feet and to vertical scale of not less than 1 inch equals 5 feet. Indicate manholes and piping. Show types, sizes, materials, and elevations of other utilities crossing system piping.

C. Product Certificates: For each type of cast-iron soil pipe and fitting, from manufacturer.

D. Field quality-control reports.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Protect pipe, pipe fittings, and seals from dirt and damage.

1.7 PROJECT CONDITIONS

A. Interruption of Existing Sanitary Sewerage 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 requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of service.

2. Do not proceed with interruption of service without Owner's written permission.

PART 2 - PRODUCTS

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

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

2.2 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 888 or CISPI 301.
- B. CISPI-Trademark, Shielded Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following
 - a. ANACO-Husky.
 - b. Dallas Specialty & Mfg. Co.
 - c. Fernco Inc.
 - d. Mission Rubber Company; a division of MCP Industries, Inc.
 - e. Stant; a Tompkins company.
 - f. Tyler Pipe.
 - 2. Description: ASTM C 1277 and CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
- C. Heavy-Duty, Shielded 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. Mission Rubber Company; a division of MCP Industries, Inc.
 - e. Stant; a Tompkins company.
 - f. Tyler Pipe.
 - 2. Description: ASTM C 1277 and ASTM C 1540, with stainless-steel shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
- D. Cast-Iron, Shielded Couplings:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. MG Piping Products Company.
 - b. Charlotte Pipe
 - c. Fernco
 - 2. Description: ASTM C 1277 with ASTM A 48/A 48M, two-piece, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.
- E. Unshielded Couplings:
- 1. Basis-of-Design Product: Subject to compliance with requirements, provide products by one of the following:
 - a. ANACO-Husky.
 - b. Charlotte Pipe
 - c. Fernco
 - 2. Description: ASTM C 1277 and ASTM C 1461, rigid, sleeve-type, reducing- or transition-type mechanical coupling, with integral, center pipe stop, molded from ASTM C 1440, TPE material; with corrosion-resistant-metal tension band and tightening mechanism on each end.

2.3 DUCTILE-IRON, GRAVITY SEWER PIPE AND FITTINGS

- A. Pipe: ASTM A 746, for push-on joints.
- B. Standard Fittings: AWWA C110, ductile or gray iron, for push-on joints.

C. Compact Fittings: AWWA C153, ductile iron, for push-on joints.

D. Gaskets: AWWA C111, rubber.

2.4 DUCTILE-IRON, PRESSURE PIPE AND FITTINGS

A. Push-on-Joint Piping:

1. Pipe: AWWA C151.
2. Standard Fittings: AWWA C110, ductile or gray iron.
3. Compact Fittings: AWWA C153.
4. Gaskets: AWWA C111, rubber, of shape matching pipe and fittings.

B. Mechanical-Joint Piping:

1. Pipe: AWWA C151, with bolt holes in bell.
2. Standard Fittings: AWWA C110, ductile or gray iron, with bolt holes in bell.
3. Compact Fittings: AWWA C153, with bolt holes in bells.
4. Glands: Cast or ductile iron; with bolt holes and high-strength, cast-iron or high-strength, low-alloy steel bolts and nuts.
5. Gaskets: AWWA C111, rubber, of shape matching pipe, fittings, and glands.

2.5 NON-PRESSURE-TYPE TRANSITION COUPLINGS

A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground non-pressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant-metal tension band and tightening mechanism on each end.

B. Sleeve Materials:

1. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
2. For Concrete Pipes: ASTM C 443, rubber.

3. For Fiberglass Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
4. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
5. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

C. Unshielded, Flexible Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Dallas Specialty & Mfg. Co.
 - b. Fernco Inc.
 - c. Logan Clay Pipe.
 - d. Mission Rubber Company; a division of MCP Industries, Inc.
 - e. NDS.
2. Description: Elastomeric sleeve with stainless-steel shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.

D. Shielded, Flexible Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cascade Waterworks Mfg.
 - b. Dallas Specialty & Mfg. Co.
 - c. Mission Rubber Company; a division of MCP Industries, Inc.
2. Description: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

E. Ring-Type, Flexible Couplings:

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

- b. Logan Clay Pipe.
 - c. Mission Rubber Company; a division of MCP Industries, Inc.
 - 2. Description: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.
- F. Non-pressure-Type, Rigid Couplings:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ANACO-Husky.
 - b. Fernco.
 - c. Charlotte Pipe
 - 2. Description: ASTM C 1461, sleeve-type, reducing- or transition-type mechanical coupling, molded from ASTM C 1440, TPE material; with corrosion-resistant-metal tension band and tightening mechanism on each end.

2.6 BACKWATER VALVES

- A. Cast-Iron Backwater Valves:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. Smith, Jay R. Mfg. Co.
 - c. Tyler Pipe.
 - d. Watts Water Technologies, Inc.
 - e. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.
 - 2. Description: ASME A112.14.1, gray-iron body and bolted cover, with bronze seat.
 - 3. Horizontal type; with swing check valve and hub-and-spigot ends.

4. Combination horizontal and manual gate-valve type; with swing check valve, integral gate valve, and hub-and-spigot ends.
5. Terminal type; with bronze seat, swing check valve, and hub inlet.

2.7 CLEANOUTS

A. Cast-Iron Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.
 - d. Tyler Pipe.
 - e. Watts Water Technologies, Inc.
 - f. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.
2. Description: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.
3. Top-Loading Classification(s): Heavy Duty [and] [Extra-Heavy Duty].
4. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Section 31 20 00 "Earth Moving."

3.2 PIPING INSTALLATION

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground sanitary sewer piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
- B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.
- C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
- D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
- E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.
- F. Install gravity-flow, nonpressure, drainage piping according to the following:
 - 1. Install piping pitched down in direction of flow, at minimum slope of 1 percent unless otherwise indicated.
 - 2. Install piping NPS 6 and larger with restrained joints at tee fittings and at changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place-concrete supports or anchors.
 - 3. Install piping with 48-inch minimum cover.
 - 4. Install hub-and-spigot, cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
 - 5. Install hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
 - 6. Install ductile-iron, gravity sewer piping according to ASTM A 746.

- G. Install force-main, pressure piping according to the following:
 - 1. Install piping with restrained joints at tee fittings and at horizontal and vertical changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place-concrete supports or anchors.
 - 2. Install piping with 48" minimum cover.
 - 3. Install ductile-iron pressure piping according to AWWA C600 or AWWA M41.
 - 4. Install ductile-iron special fittings according to AWWA C600.
- H. Install corrosion-protection piping encasement over the following underground metal piping according to ASTM A 674 or AWWA C105:
 - 1. Hub-and-spigot, cast-iron soil pipe.
 - 2. Hubless cast-iron soil pipe and fittings.
 - 3. Ductile-iron pipe and fittings.
 - 4. Expansion joints and deflection fittings.
- I. Clear interior of piping and manholes of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

3.3 PIPE JOINT CONSTRUCTION

- A. Join gravity-flow, non-pressure, drainage piping according to the following:
 - 1. 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.
 - 2. 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.
 - 3. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

4. Join ductile-iron, gravity sewer piping according to AWWA C600 for push-on joints.
 5. Join dissimilar pipe materials with nonpressure-type, flexible couplings.
- B. Join force-main, pressure piping according to the following:
1. Join ductile-iron pressure piping according to AWWA C600 or AWWA M41 for push-on joints.
 2. Join ductile-iron special fittings according to AWWA C600 or AWWA M41 for push-on joints.
 3. Join dissimilar pipe materials with pressure-type couplings.
- C. Pipe couplings, expansion joints, and deflection fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
1. Use nonpressure flexible couplings where required to join gravity-flow, nonpressure sewer piping unless otherwise indicated.
 - a. Shielded flexible couplings for pipes of same or slightly different OD.
 - b. Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.
 - c. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.
 2. Use pressure pipe couplings for force-main joints.

3.4 BACKWATER VALVE INSTALLATION

- A. Install horizontal-type backwater valves in piping manholes or pits.
- B. Install combination horizontal and manual gate valves in piping and in manholes.
- C. Install terminal-type backwater valves on end of piping and in manholes. Secure units to sidewalls.

3.5 CLEANOUT INSTALLATION

- A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts, and use cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
 - 1. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.
 - 2. Use Extra-Heavy-Duty, top-loading classification cleanouts in roads.

3.6 CONNECTIONS

- A. Connect non-pressure, gravity-flow drainage piping to building's sanitary building drains specified in Section 22 13 16 "Sanitary Waste and Vent Piping."
- B. Connect force-main piping to building's sanitary force mains specified in Section 22 13 16 "Sanitary Waste and Vent Piping." Terminate piping where indicated.
- C. Make connections to existing piping and underground manholes.
 - 1. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye fitting plus 6-inch (150-mm) overlap with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
 - 2. Make branch connections from side into existing piping, NPS 4 to NPS 20 (DN 100 to DN 500). Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
 - 3. Make branch connections from side into existing piping, NPS 21 (DN 525) or larger, or to underground manholes by cutting opening into existing unit large enough to allow 3 inches (76 mm) of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall unless otherwise indicated. On outside of pipe or manhole wall, encase entering connection in 6 inches (150 mm) of concrete for minimum length of 12 inches (300 mm) to provide additional support of collar from connection to undisturbed ground.

- a. Use concrete that will attain a minimum 28-day compressive strength of 3000 psi (20.7 MPa) unless otherwise indicated.
 - b. Use epoxy-bonding compound as interface between new and existing concrete and piping materials.
4. Protect existing piping and manholes to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

3.7 IDENTIFICATION

- A. Comply with requirements in Section 31 20 00 "Earth Moving" for underground utility identification devices. Arrange for installation of green warning tapes directly over piping and at outside edges of underground manholes.
 1. Use warning tape or detectable warning tape over ferrous piping.
 2. Use detectable warning tape over nonferrous piping and over edges of underground manholes.

3.8 FIELD QUALITY CONTROL

- A. Inspect interior of 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. Submit separate report for each system inspection.
 2. Defects requiring correction include the following:
 - a. Alignment: Less than full diameter of inside of pipe is visible between structures.
 - 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. Damage: Crushed, broken, cracked, or otherwise damaged piping.
 - d. Infiltration: Water leakage into piping.
 - e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
 4. Reinspect and repeat procedure until results are satisfactory.
- B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
1. Do not enclose, cover, or put into service before inspection and approval.
 2. Test completed piping systems according to requirements of authorities having jurisdiction.
 3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
 4. Submit separate report for each test.
 5. Hydrostatic Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction and the following:
 - a. Fill sewer piping with water. Test with pressure of at least 10-foot head of water, and maintain such pressure without leakage for at least 15 minutes.
 - b. Close openings in system and fill with water.
 - c. Purge air and refill with water.
 - d. Disconnect water supply.
 - e. Test and inspect joints for leaks.
 6. Force Main: Perform hydrostatic test after thrust blocks, supports, and anchors have hardened. Test at pressure not less than 1-1/2 times the maximum system operating pressure, but not less than 150 psig
 - a. Ductile-Iron Piping: Test according to AWWA C600, "Hydraulic Testing" Section.
- C. Leaks and loss in test pressure constitute defects that must be repaired.
- D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.9 CLEANING

- A. Clean dirt and superfluous material from interior of piping. Flush with potable water.

END OF SECTION

SECTION 22 13 16

SANITARY WASTE AND VENT PIPING AND SPECIALTIES

(Part of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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. Backwater valves
- 5. Cleanouts.
- 6. Floor drains.
- 7. Trench drains.
- 8. Channel drainage systems.
- 9. Air-admittance valves.
- 10. Roof flashing assemblies.

11. Through-penetration fire-stop assemblies.
12. Miscellaneous sanitary drainage piping specialties.
13. Flashing materials.
14. Solids interceptors.

B. Related Sections:

1. Division 22 Section "Facility Sanitary Sewers" for sanitary sewerage piping and structures outside the building.
2. Division 22 Section "Sanitary Sewerage Pumps" for effluent and sewage pumps.
3. Division 22 Section "Facility Storm Drainage Piping and Specialties" for storm drainage piping inside the building, drainage piping specialties and drains.
4. Division 22 Section "Plumbing Fixtures" for hair interceptors.

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
- B. Seismic Performance: Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1.4 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. FOG: Fats, oils, and greases.
- C. FRP: Fiberglass-reinforced plastic.

- D. HDPE: High-density polyethylene plastic.
- E. PE: Polyethylene plastic.
- F. PP: Polypropylene plastic.
- G. PVC: Polyvinyl chloride plastic.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated Include rated capacities, operating characteristics, and accessories for the following:
 - 1. Gas and Sand interceptors.

1.6 INFORMATIONAL SUBMITTALS

- A. Manufacturer Seismic Qualification Certification: Submit certification that piping, equipment, accessories, and components will withstand seismic forces defined in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment." Include the following:
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. 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."
 - 2. Dimensioned Outline Drawings of Equipment Unit (where applicable): 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.
- B. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. All cast iron soil pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute (CISPI) and be listed by NSF International.
- C. Comply with NSF/ANSI 14, "Plastics Piping Systems Components and Related Materials," for plastic piping and specialty components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.
- D. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.9 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate size and location of roof penetrations.

1.10 PROJECT CONDITIONS

- A. Interruption of Existing Sanitary Waste 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 requirements indicated:
 - 1. Notify Owner no fewer than two days in advance of proposed interruption of sanitary waste service.
 - 2. Do not proceed with interruption of sanitary waste service without Owner's written permission.

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; a division of MCP Industries, Inc.
 - f. Stant.
 - g. Tyler Pipe.
 - 2. Standards: ASTM C 1277 and ASTM C 1540.
 - 3. Description: Stainless-steel shield with four (4) stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
- C. Cast-Iron, Hubless-Piping Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. MG Piping Products Company.
 - 2. Standard: ASTM C 1277.

3. Description: Two-piece ASTM A 48/A 48M, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.3 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.
 3. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.4 SPECIALTY PIPE FITTINGS

- A. 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, Non-pressure 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) Mission Rubber Company; a division of MCP Industries, Inc.
 - 4) Plastic Oddities; a division of Diverse Corporate Technologies, Inc.
 - 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, Non-pressure 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; a division of MCP Industries, Inc.
 - 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) JCM Industries, Inc.

- 5) Romac Industries, Inc.
 - 6) Smith-Blair, Inc.; a Sensus company.
 - 7) The Ford Meter Box Company, 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.
- B. 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) Capitol Manufacturing Company.
 - 2) Central Plastics Company.
 - 3) Hart Industries International, Inc.
 - 4) Jomar International Ltd.
 - 5) Matco-Norca, Inc.
 - 6) McDonald, A. Y. Mfg. Co.
 - 7) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - 8) Wilkins; a Zurn company.
 - b. Description:
 - 1) Standard: ASSE 1079.
 - 2) Pressure Rating: 50 psig.

- 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, Inc.
 - 4) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - 5) Wilkins; a Zurn company.
- b. Description:
 - 1) Standard: ASSE 1079.
 - 2) Factory-fabricated, bolted, companion-flange assembly.
 - 3) Pressure Rating: 50 psig.
 - 4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

4. Dielectric-Flange Insulating Kits:

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

5. Dielectric Nipples:

- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Elster Perfection.
 - 2) Grinnell Mechanical Products.
 - 3) Matco-Norca, Inc.
 - 4) Precision Plumbing Products, Inc.
 - 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.

2.5 BACKWATER VALVES

A. Horizontal, Cast-Iron Backwater Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfr. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; Wade Div.
 - e. Watts Drainage Products Inc.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
- 2. Standard: ASME A112.14.1.
- 3. Size: Same as connected piping.

4. Body: Cast iron.
5. Cover: Cast iron with bolted or threaded access check valve.
6. End Connections: Hub and spigot or hubless.
7. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang closed.
8. Extension: ASTM A 74, Service class; full-size, cast-iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

2.6 CLEANOUTS

A. Exposed Metal Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; Wade Div.
 - e. Watts Drainage Products Inc.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
 - g. Josam Company; Blucher-Josam Div.
2. Standard: ASME A112.36.2M for cast iron; ASME A112.3.1 for stainless steel
3. Size: Same as connected drainage piping
4. Body Material: Hubless, cast-iron soil pipe test tee or Stainless-steel tee with side cleanout as required to match connected piping.
5. Closure: Countersunk, brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

7. Closure for Stainless Steel cleanouts: Stainless-steel plug with seal.

B. Metal Floor Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Div.
 - b. Oatey.
 - c. Sioux Chief Manufacturing Company, Inc.
 - d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - e. Tyler Pipe; Wade Div.
 - f. Watts Drainage Products Inc.
 - g. Zurn Plumbing Products Group; Light Commercial Operation.
 - h. Zurn Plumbing Products Group; Specification Drainage Operation.
 - i. Josam Company; Josam Div.
 - j. Kusel Equipment Co.
 - k. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
2. Standard: ASME A112.36.2M for cast-iron soil pipe with cast-iron ferrule heavy-duty, adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Cast-iron soil pipe with cast-iron ferrule Heavy-duty, adjustable housing.
5. Body or Ferrule: Cast iron.
6. Clamping Device: Required.
7. Outlet Connection: Inside calk or Spigot.
8. Closure: Brass plug with straight threads and gasket, Cast-iron plug.
9. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.

11. Frame and Cover Shape: Round.
12. Top Loading Classification: Heavy Duty.
13. Riser: ASTM A 74, Extra-Heavy class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; Wade Div.
 - e. Watts Drainage Products Inc.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk, drilled-and-threaded, 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: Square, nickel-bronze, copper-alloy, or stainless-steel wall-installation frame and cover.

2.7 FLOOR DRAINS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; Wade Div.
 - e. Watts Drainage Products Inc.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
- B. Provide with trap primer connection

2.8 TRENCH DRAINS

- A. Trench Drains:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Scheir
 - e. Tyler Pipe; Wade Div.
 - f. Watts Drainage Products Inc.
 - g. Zurn Plumbing Products Group; Specification Drainage Operation.
 - 2. Standard: ASME A112.6.3 for trench drains.
 - 3. Material: Ductile or gray iron.
 - 4. Outlet: Bottom or side
 - 5. Grate Material: Stainless steel, heavy duty

2.9 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Acorn Engineering Company; Elmdor/Stoneman Div.
 - b. Thaler Metal Industries Ltd.
 - c. Oatey

B. Description: Manufactured assembly made of 6.0-lb/sq. ft., 0.0938-inch thick, lead flashing collar and skirt extending at least 8 inches from pipe, with galvanized-steel boot reinforcement and counter-flashing fitting.

1. Open-Top Vent Cap: Without cap.
2. Low-Silhouette Vent Cap: With vandal-proof vent cap.
3. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.10 THROUGH-PENETRATION FIRE-STOP ASSEMBLIES

A. Through-Penetration Fire-stop Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. ProSet Systems Inc.
 - b. 3M
 - c. Hilti
2. Standard: UL 1479 assembly of sleeve and stack fitting with fire-stopping 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.

2.11 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 with increaser fitting of size indicated.

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 1 inch 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 stacks piping.

E. Stack Flashing Fittings:

1. Description: Counter-flashing-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.

G. Frost-Resistant Vent Terminals:

1. Description: Manufactured or shop-fabricated assembly constructed of copper, lead-coated copper, or galvanized steel.
2. Design: To provide 1-inch enclosed air space between outside of pipe and inside of flashing collar extension, with counter-flashing.

H. Expansion Joints:

1. Standard: ASME A112.21.2M.
2. Body: Cast iron with bronze sleeve, packing, and gland.
3. End Connections: Matching connected piping.
4. Size: Same as connected soil, waste, or vent piping.

PART 3 - EXECUTION

3.1 EARTH MOVING

- A. Comply with requirements for excavating, trenching, and backfilling specified in Division 31 Section "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 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. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- K. 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.

- L. 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.
- M. 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; 1 percent downward in direction of flow for piping NPS 4 and larger.
 - 2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
 - 3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
- N. 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.
- O. Install steel piping according to applicable plumbing code.
- P. Install stainless-steel piping according to ASME A112.3.1 and applicable plumbing code.
- Q. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."
- R. Install engineered soil and waste drainage and vent piping systems as follows:
 - 1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.

2. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.
- S. Install underground, ductile-iron, 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.
1. Install encasement on piping according to ASTM A 674 or AWWA C105/A 21.5.
- T. Install underground, copper, force-main tubing according to CDA's "Copper Tube Handbook."
1. Install encasement on piping according to ASTM A 674 or AWWA C105/A 21.5.
- U. Install force mains at elevations indicated.
- V. Plumbing Specialties:
1. Install backwater valves in sanitary waste gravity-flow piping. Comply with requirements for backwater valves specified in Division 22 Section "Sanitary Waste Piping Specialties."
 2. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping. Comply with requirements for cleanouts specified in Division 22 Section "Sanitary Waste Piping Specialties."
 3. Install drains in sanitary drainage gravity-flow piping. Comply with requirements for drains specified in Division 22 Section "Sanitary Waste Piping Specialties."
- W. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- X. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

- Y. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."
- Z. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight.
- AA. Install wall-penetration fitting system at each service pipe penetration through foundation wall. Make installation watertight.
- BB. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

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 stainless-steel pipe and fittings with gaskets according to ASME A112.3.1.
- F. 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.

- G. 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.
- H. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.

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: Shielded, non-pressure 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 unions.
- 3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.
- 4. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 VALVE INSTALLATION

- A. General valve installation requirements are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
- B. 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.
- C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.
- D. Backwater Valves: Install backwater valves in piping subject to backflow.
1. Horizontal Piping: Horizontal backwater valves.
 2. Floor Drains: Drain outlet backwater valves unless drain has integral backwater valve.
 3. Install backwater valves in accessible locations.
 4. Comply with requirements for backwater valve specified in Division 22 Section "Sanitary Waste Piping Specialties."

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for seismic-restraint devices specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- B. Comply with requirements for pipe hanger and support devices and installation specified in Division 22 Section "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.
- C. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.
- D. Support vertical piping and tubing at base and at each floor.
- E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.
- F. 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.
- G. Install supports for vertical cast-iron soil piping every 15 feet.
- H. 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.
- I. Install supports for vertical steel piping every 15 feet.
- J. Install hangers for stainless-steel piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 2: 84 inches with 3/8-inch rod.
 2. NPS 3: 96 inches with 1/2-inch rod.
 3. NPS 4: 108 inches with 1/2-inch rod.
 4. NPS 6: 10 feet with 5/8-inch rod.
- K. Install supports for vertical stainless-steel piping every 10 feet.
- L. 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.

M. Install supports for vertical copper tubing every 10 feet.

N. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.7 EQUIPMENT/SPECIALTY INSTALLATION

A. Install backwater valves in building drain piping. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.

B. 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.

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 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. Set with grates depressed according to the following drainage area radii:

a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.

- b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
 - c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
- 3. Install floor-drain flashing collar or flange 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.
- F. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface, unless otherwise indicated.
 - G. Assemble and install stainless-steel channel drainage systems according to ASME A112.3.1. Install on support devices so that top will be flush with surface.
 - H. Assemble FRP channel drainage system components according to manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.
 - I. Assemble plastic channel drainage system components according to manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.
 - J. Install fixture air-admittance valves on fixture drain piping.
 - K. Install stack air-admittance valves at top of stack vent and vent stack piping.
 - L. Install air-admittance-valve wall boxes recessed in wall.
 - M. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.
 - N. Install through-penetration fire-stop assemblies in plastic conductors and stacks at floor penetrations.
 - O. Assemble open drain fittings and install with top of hub 1 inch above floor.
 - P. Install deep-seal traps on floor drains and other waste outlets, if indicated.
 - Q. 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.
 - R. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
 - S. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.
 - T. Install vent caps on each vent pipe passing through roof.
 - U. Install frost-resistant vent terminals on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.
 - V. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.
 - W. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.
 - X. Assemble components of FOG disposal systems and install on floor. Install trap, vent, fresh-air inlet, and flow-control fitting according to authorities having jurisdiction. Install shelf fastened to reinforcement in wall construction and adjacent to unit, unless otherwise indicated. Install culture bottle, culture metering pump, timer, and control on shelf. Install tubing between culture bottle, metering pump, and chamber.
 - Y. Install solids interceptors with cleanout immediately downstream from interceptors that do not have integral cleanout on outlet. Install trap on interceptors that do not have integral trap and are connected to sanitary drainage and vent systems.
 - Z. Install wood-blocking reinforcement for wall-mounting-type specialties.
 - AA. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.
- 3.8 CONNECTIONS
- A. Drawings indicate general arrangement of piping, fittings, and specialties.
 - B. Install piping adjacent to equipment to allow service and maintenance.

- C. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- D. 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 Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
 - 3. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
 - 4. Install horizontal backwater valves with cleanout cover flush with floor.
 - 5. Comply with requirements for backwater valves, cleanouts and drains specified in Division 22 Section "Sanitary Waste Piping Specialties."
 - 6. Equipment: Connect drainage piping as indicated. Provide shutoff valve if indicated and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.
- E. Connect force-main piping to the following:
 - 1. Sanitary Sewer: To exterior force main.
 - 2. Sewage Pump: To sewage pump discharge.
- F. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
- G. 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.
- H. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

- I. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.9 LABELING AND IDENTIFICATION

- A. Identify exposed sanitary waste and vent piping. Comply with requirements for identification specified in Division 22 Section "Identification for Plumbing Piping and Equipment."
- B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
 1. Solids interceptors.
- C. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.10 FIELD QUALITY CONTROL

- A. During piping 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. Re-inspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for re-inspection.
- 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.

3.11 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.
- D. Exposed ABS and PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.
- E. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- F. Place plugs in ends of uncompleted piping at end of each day or when work stops.

3.12 PIPING SCHEDULE

- A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. Aboveground, soil and waste 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.
 4. Dissimilar Pipe-Material Couplings: Shielded, non-pressure transition couplings.
- C. Aboveground, vent piping NPS 4 and smaller 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.
 - a. Option for Vent Piping, NPS 2-1/2 and NPS 3-1/2: Hard copper tube, Type M; copper pressure fittings; and soldered joints.
 4. Dissimilar Pipe-Material Couplings: Shielded, non-pressure transition couplings.
- D. Aboveground, vent piping NPS 5 and larger shall be any of the following:
1. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
 2. Dissimilar Pipe-Material Couplings: Shielded, non-pressure transition couplings.
- E. Underground, soil, waste, and vent piping shall be any of the following:
1. Service class, cast-iron soil piping; calking materials; and calked joints.
 2. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
 3. Stainless-steel pipe and fittings, gaskets, and gasketed joints.
 4. Dissimilar Pipe-Material Couplings: Shielded, non-pressure transition couplings.
- F. Aboveground sanitary-sewage force mains NPS 2-1/2 to NPS 6 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.
- G. Underground sanitary-sewage force mains NPS 4 and smaller shall be any of the following:
1. Hard copper tube, Type L; wrought-copper pressure fittings; and soldered joints.
 2. Ductile-iron, mechanical-joint piping and mechanical joints.

3. Fitting-type transition coupling for piping smaller than NPS 1-1/2 and pressure transition coupling for NPS 1-1/2 and larger if dissimilar pipe materials.

END OF SECTION

SECTION 22 13 29

SANITARY SEWERAGE PUMPS

(Part of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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. Submersible sewage pumps.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Wiring Diagrams: For power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

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

1.5 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. UL Compliance: Comply with UL 778 for motor-operated water pumps.

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 rigging instructions for handling.

1.7 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 SUBMERSIBLE SEWAGE PUMPS

- A. Submersible, Quick-Disconnect, Sewage Pumps:
 - 1. Manufacturers:
 - a. Stancor
 - b. Weil Pump Company
 - c. Grundfos
 - d. Approved equal
 - 2. Description: Factory-assembled and -tested sewage-pump unit with guide-rail supports.
 - 3. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sewage pump as defined in HI 1.1-1.2 and HI 1.3.

4. Pump Casing: Cast iron, with open inlet, and discharge fittings for connection to guide-rail support.
5. Impeller: Statically and dynamically balanced, stainless steel, nonclog, open, or semiopen design for solids handling, and keyed and secured to shaft.
6. Pump and Motor Shaft: Stainless, with factory-sealed, grease-lubricated ball bearings.
7. Seal: Mechanical.
8. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
9. Controls:
 - a. Enclosure: NEMA 250, Type 1; wall-mounted.
 - b. Switch Type: Mechanical-float type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
 - c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - d. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float switch matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
10. Control-Interface Features:
 - a. Remote Alarm Contacts: For remote alarm interface.
 - b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - 1) On-off status of pump.
 - 2) Alarm status.
11. Guide-Rail Supports:
 - a. Standard: SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook."

- b. Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
- c. Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
- d. Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
- e. Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
- f. Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.
- g. Lifting Cable: Stainless steel; attached to pump and cover at manhole.

2.2 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 22 0513 "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.
- B. Motors for submersible pumps shall be hermetically sealed.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavation and filling are specified in Section 31 2000 "Earth Moving."

3.2 EXAMINATION

- A. Examine roughing-in for plumbing piping to verify actual locations of sanitary drainage and vent piping connections before sewage pump installation.

3.3 INSTALLATION

A. Pump Installation Standards:

1. Comply with HI 1.4 for installation of centrifugal pumps.
2. Comply with HI 3.1-3.5 for installation of progressing-cavity sewage pumps.

B. Equipment Mounting:

1. Comply with requirements for vibration isolation and seismic control devices specified in Section 22 0548 "Vibration and Seismic Controls for Plumbing Piping and Equipment"

C. Wiring Method: Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

D. 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.

3.4 CONNECTIONS

A. Comply with requirements for piping specified in Section 22 1316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

3.5 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. 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 motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Pumps and controls will be considered defective if they do not pass tests and inspections.

E. 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.

3.7 ADJUSTING

A. Adjust pumps to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust control set points.

3.8 DEMONSTRATION

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

END OF SECTION

SECTION 22 14 13

FACILITY STORM DRAINAGE PIPING AND SPECIALTIES

(Part of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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. Miscellaneous storm drainage piping specialties.
5. Cleanouts.
6. Backwater valves.
7. Through-penetration fire-stop assemblies.
8. Flashing materials.

B. Related Sections:

1. Division 33 Section "Storm Utility Drainage Piping" for storm drainage piping outside the building.
2. Division 22 Section "Sanitary Waste and Vent Piping and Specialties" for floor drains, area drains and all other drainage systems connected to sanitary sewer.

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: 15-foot head of water. Storm Drainage, Force-Main Piping 100 psig
- B. Seismic Performance: Storm drainage piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures" and per authority having jurisdiction.

1.4 ACTION SUBMITTALS

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

1.5 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For storm drainage piping, 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. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Field quality-control and test reports.

1.6 QUALITY ASSURANCE

- A. Piping materials and specialties shall bear label, stamp, or other markings of specified testing agency.
- B. All cast iron soil pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute (CISPI) and be listed by NSF International.
- C. Product Data: For each type of product indicated.

1.7 COORDINATION

- A. Coordinate size and location of all roof penetrations.

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. All pipe and fittings shall be marked with CISPI's collective trademark or receive prior approval by the engineer of record.
- B. Heavy-Duty, Shielded Cast-Iron, Hubless Piping Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. MG Piping Products Company.
 - b. Tyler Pipe
 - c. MIFAB, Inc.
 - 2. Description: Two-piece ASTM A 48/A 48M, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.3 SPECIALTY PIPE FITTINGS

- A. 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, Non-pressure 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) Mission Rubber Company; a division of MCP Industries, Inc.
 - 4) Plastic Oddities; a division of Diverse Corporate Technologies, Inc.
 - 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 Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
4. Shielded, Non-pressure 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; a division of MCP Industries, Inc.
 - 3) Fernco
 - 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) JCM Industries, Inc.
 - 6) Romac Industries, Inc.
 - 7) Smith-Blair, Inc.; a Sensus company.
 - 8) Viking Johnson; c/o Mueller Co.
- b. Standard: AWWA C219.
- c. Description: Metal, sleeve-type couplings 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.

B. 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) Capitol Manufacturing Company.
 - 2) Central Plastics Company.
 - 3) Hart Industries International, Inc.
 - 4) Jomar International Ltd.

- 5) Matco-Norca, Inc.
 - 6) McDonald, A. Y. Mfg. Co.
 - 7) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - 8) Wilkins; a Zurn company.
 - b. Description:
 - 1) Standard: ASSE 1079.
 - 2) Pressure Rating: 150 psig 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, Inc.
 - 4) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - 5) Wilkins; a Zurn company.
 - b. Description:
 - 1) Standard: ASSE 1079.
 - 2) Factory-fabricated, bolted, companion-flange assembly.
 - 3) Pressure Rating: 150 psig.
 - 4) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
4. Dielectric-Flange Insulating Kits:
- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Advance Products & Systems, Inc.
 - 2) Calpico, Inc.
 - 3) Central Plastics Company.

- 4) Pipeline Seal and Insulator, Inc.
 - b. Description:
 - 1) Non-conducting materials for field assembly of companion flanges.
 - 2) Pressure Rating: 150 psig.
 - 3) Gasket: Neoprene or phenolic.
 - 4) Bolt Sleeves: Phenolic or polyethylene.
 - 5) Washers: Phenolic with steel-backing washers.
5. Dielectric Nipples:
- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Elster Perfection.
 - 2) Grinnell Mechanical Products.
 - 3) Matco-Norca, Inc.
 - 4) Precision Plumbing Products, Inc.
 - 5) Victaulic Company.
 - b. Description:
 - 1) Electroplated steel nipple complying with ASTM F 1545.
 - 2) Pressure Rating: 300 psig at 225 deg F.
 - 3) End Connections: Male threaded or grooved.
 - 4) Lining: Inert and noncorrosive, propylene.

2.4 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Downspout Adaptors:

- 1. Description: Manufactured, gray-iron casting, for attaching to horizontal-outlet, parapet roof drain and to exterior, sheet metal downspout.
- 2. Size: Inlet size to match parapet drain outlet.

B. Downspout Boots:

1. Description: Manufactured, ASTM A 48/A 48M, gray-iron casting, with strap or ears for attaching to building; NPS 4 outlet; and shop-applied bituminous coating.
2. Size: Inlet size to match downspout and NPS 4 outlet.

C. Conductor Nozzles:

1. Description: Bronze body with threaded inlet and bronze wall flange with mounting holes.
2. Size: Same as connected conductor.

D. Expansion Joints:

1. Standard: ASME A112.21.2M.
2. Body: Cast iron with bronze sleeve, packing, and gland.
3. End Connections: Matching connected piping.
4. Size: Same as connected piping.

2.5 CLEANOUTS

A. Floor Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. Smith, Jay R. Mfg. Co.
 - c. MIFAB, Inc.
 - d. Watts Water Technologies, Inc.
 - e. Zurn Plumbing Products Group.
2. Standard: ASME A112.36.2M
3. Size: Same as connected branch.
4. Type: Cast-iron soil pipe with cast-iron ferrule.
5. Body or Ferrule Material: Cast iron.
6. Clamping Device: Required.
7. Outlet Connection: Inside calk.
8. Closure: Brass plug with straight threads and gasket.
9. Adjustable Housing Material: Cast iron with set-screws or other device.

10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
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. Wall Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.
 - d. Tyler Pipe.
 - e. Watts Water Technologies, Inc.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M, for cleanouts. Include wall access.
3. Size: Same as connected drainage piping.
4. Body Material: Hubless, cast-iron soil-pipe test tee as required to match connected piping.
5. Closure: Countersunk or raised-head, cast-iron 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.

2.6 THROUGH-PENETRATION FIRE-STOP ASSEMBLIES

A. Through-Penetration Fire-stop Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ProSet Systems Inc.
 - b. 3M
 - c. Hilti

d. Or approved equal

2. Standard: UL 1479 assembly of sleeve and stack fitting with fire-stopping plug.
3. Size: Same as connected pipe.
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.

2.7 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. Fasteners: Metal compatible with material and substrate being fastened.
- D. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
- E. Solder: ASTM B 32, lead-free alloy.
- F. 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 Division 31 Section "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. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- K. 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.
- L. 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.

- M. Install storm drainage piping at the following minimum slopes unless otherwise indicated:
 - 1. Building Storm Drain: Slope downward in direction of flow for piping as required by code and per authority having jurisdiction.
- N. 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."
- O. Install underground storm drainage piping according to ASTM D 2321.
- P. Plumbing Specialties:
 - 1. Install backwater valves in storm drainage gravity-flow piping. Comply with requirements for backwater valves specified in Division 22 Section "Storm Drainage Piping Specialties."
 - 2. 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. Comply with requirements for cleanouts specified in Division 22 Section "Storm Drainage Piping Specialties."
 - 3. Install drains in storm drainage gravity-flow piping. Comply with requirements for drains specified in Division 22 Section "Storm Drainage Piping Specialties."
- Q. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."
- S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."
- T. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight.

- U. Install wall-penetration fitting system at each service pipe penetration through foundation wall. Make installation watertight.
- V. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
- W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."
- X. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers.
- Y. Provide insulation on all storm drainage piping and fittings below roof.

3.3 JOINT CONSTRUCTION

- A. 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.
- B. 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.

3.4 PIPE FITTING INSTALLATION

- A. Transition Couplings:
 - 1. Install transition couplings at joints of piping with small differences in OD's.
 - 2. In Drainage Piping: Shielded, non-pressure transition couplings.
 - 3. In Aboveground Force-Main Piping: Fitting-type transition couplings.
 - 4. In Underground Force-Main Piping:
 - a. 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 2-1/2 to NPS 4: Use dielectric flanges.
3. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 VALVE INSTALLATION

- A. General valve installation requirements are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
- B. Shutoff Valves: Install shutoff valve on each sump pump discharge.
1. Install gate valve for piping NPS 2-1/2 and larger.
- C. Check Valves: Install swing-check valve, between pump and shutoff valve, on each sump pump discharge.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for seismic-restraint devices specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- B. Comply with requirements for pipe hanger and support devices and installation specified in Division 22 Section "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.
- 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.
- C. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.
- D. Support vertical piping and tubing at base and at each floor.
- E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.
- F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 3 : 60 inches with 1/2-inch rod.
 - 2. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
 - 3. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
 - 4. NPS 10 and NPS 12: 60 inches with 7/8-inch rod.
 - 5. Spacing for 10-foot pipe lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- G. Install supports for vertical cast-iron soil piping every 15 feet .
- H. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/2: 108 inches with 3/8-inch rod.
 - 2. NPS 2: 10 feet with 3/8-inch rod.
 - 3. NPS 2-1/2: 11 feet with 1/2-inch rod.
 - 4. NPS 3: 12 feet with 1/2-inch rod.
 - 5. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
 - 6. NPS 6 and NPS 8: 12 feet with 3/4-inch rod.
 - 7. NPS 10 and NPS 12: 12 feet with 7/8-inch rod.
- I. Install supports for vertical steel piping every 15 feet.
- J. 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 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. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
- E. 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 storm drainage piping. Comply with requirements for identification specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.9 STORM DRAINAGE SPECIALTY INSTALLATION

- A. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions. Roofing materials are specified in Division 07 Sections.
 - 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 downspout adapters on outlet of back-outlet parapet roof drains and connect to sheet metal downspouts.
- C. Install downspout boots at grade with top 6 inches above grade. Secure to building wall.
- D. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.
- E. 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.
- F. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- G. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- H. Install horizontal backwater valves in floor with cover flush with floor.
- I. Install drain-outlet backwater valves in outlet of drains.
- J. Install test tees in vertical conductors and near floor.
- K. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.
- L. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface unless otherwise indicated.
- M. Install through-penetration fire-stop assemblies in plastic conductors at concrete floor penetrations.
- N. Install sleeve flashing device with each conductor passing through floors with waterproof membrane.

- O. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

3.10 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, and specialties passing through or embedded in floors and roofs with waterproof membrane.
 - 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.

3.11 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. Re-inspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for re-inspection.
- 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, 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 15-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.

3.12 PIPE 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.

3.13 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.

3.14 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. Dissimilar Pipe-Material Couplings: Shielded, non-pressure transition couplings.
- C. Underground storm drainage piping shall be the following:
 - 1. Hubless, cast-iron soil pipe and fittings; heavy-duty, cast-iron, hubless-piping couplings; and coupled joints.
 - 2. Dissimilar Pipe-Material Couplings: Shielded, non-pressure transition couplings.
- D. Aboveground storm drainage force mains shall be following:
 - 1. Galvanized-steel pipe, pressure fittings, and threaded joints.
 - 2. Fitting-type transition couplings if dissimilar pipe materials.

E. Underground storm drainage force mains shall be the following:

1. Ductile-iron, mechanical-joint piping and mechanical joints.
2. Fitting-type transition coupling for piping smaller than NPS 1-1/2 and pressure transition coupling for NPS 1-1/2 and larger if dissimilar pipe materials.

END OF SECTION

SECTION 22 33 00

ELECTRIC, DOMESTIC-WATER HEATERS

(Part of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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. Commercial, electric, storage, domestic-water heaters.
 - 2. Domestic-water heater accessories.

1.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Commercial domestic-water heaters 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."

1.4 ACTION SUBMITTALS

- A. Product Data: For each type and size of domestic-water heater indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For commercial domestic-water heaters, 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.
- B. Product Certificates: For each type of commercial, electric, domestic-water heater, from manufacturer.
- C. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.
- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For electric, domestic-water heaters to include in emergency, operation, and maintenance manuals.

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/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.
- C. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61, "Drinking Water System Components - Health Effects."

1.8 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric, domestic-water heaters that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures including storage tank and supports.
 - b. Faulty operation of controls.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
 - 2. Warranty Periods: From date of Substantial Completion.
 - a. Commercial, Electric, Storage, Domestic-Water Heaters:
 - 1) Storage Tank: Five years.
 - 2) Controls and Other Components: Five years.

PART 2 - PRODUCTS

2.1 COMMERCIAL, ELECTRIC, DOMESTIC -WATER HEATERS

- A. Commercial, Light-Duty, Storage, Electric, Domestic-Water Heaters:

ELECTRICAL DOMESTIC WATER HEATERS

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. PVI.
 - b. Lochinvar Corporation.
 - c. Smith, A. O. Water Products Co.; a division of A. O. Smith Corporation.
 - d. State Industries.
 - e. Bradford White Corporation.
3. Standard: UL 174.
4. Storage-Tank Construction: Steel, vertical arrangement.
 - a. Tappings: ASME B1.20.1 pipe thread.
 - b. Pressure Rating: 150 psig.
 - c. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
5. Factory-Installed Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: ASSE 1005.
 - d. Insulation: Comply with ASHRAE/IESNA 90.1 or ASHRAE 90.2.
 - e. Jacket: Steel with enameled finish.
 - f. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
 - g. Heating Elements: Two; electric, screw-in immersion type; wired for simultaneous operation unless otherwise indicated. Limited to 12 kW total.
 - h. Temperature Control: Adjustable thermostat.
 - i. Safety Control: High-temperature-limit cutoff device or system.

- j. Relief Valve: ASME rated and stamped for combination temperature-and-pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.

2.2 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Compression Tanks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis-of-Design Product: Subject to compliance with requirements, comparable product by one of the following:
 - a. AMTROL Inc.
 - b. Flexcon Industries.
 - c. Honeywell International Inc.
 - d. Smith, A. O. Water Products Co.; a division of A. O. Smith Corporation.
 - e. State Industries.
3. Description: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
4. Construction:
 - a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
 - b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Air-Charging Valve: Factory installed.

- ### B. Drain Pans: Corrosion-resistant metal with raised edge. Comply with ANSI/CSA LC 3. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than NPS 3/4 with ASME B1.20.1 pipe threads or with ASME B1.20.7 garden-hose threads.

- C. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.
- D. Heat-Trap Fittings: ASHRAE 90.2.
- E. Manifold Kits: Domestic-water heater manufacturer's factory-fabricated inlet and outlet piping for field installation, for multiple domestic-water heater installation. Include ball-, butterfly-, or gate-type shutoff valves to isolate each domestic-water heater and memory-stop balancing valves to provide balanced flow through each domestic-water heater.
 - 1. Comply with requirements for ball-, butterfly-, or gate-type shutoff valves specified in Section 22 05 23 "General-Duty Valves for Plumbing Piping."
 - 2. Comply with requirements for balancing valves specified in Section 22 11 19 "Domestic Water Piping Specialties."
- F. Pressure-Reducing Valves: ASSE 1003 for water. Set at 25-psig- maximum outlet pressure unless otherwise indicated.
- G. Combination Temperature-and-Pressure Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.
- H. Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than domestic-water heater working-pressure rating.
- I. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.
- J. Shock Absorbers: ASSE 1010 or PDI-WH 201, Size A water hammer arrester.
- K. Domestic-Water Heater Stands: Manufacturer's factory-fabricated steel stand for floor mounting, capable of supporting domestic-water heater and water. Include dimension that will support bottom of domestic-water heater a minimum of 18 inches above the floor.
- L. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.

2.3 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect domestic-water heaters specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.
- B. Hydrostatically test commercial domestic-water heaters to minimum of one and one-half times pressure rating before shipment.
- C. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 01 40 00 "Quality Requirements" for retesting and reinspecting requirements and Section 01 73 00 "Execution" for requirements for correcting the Work.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

- A. Commercial, Electric, Domestic-Water Heater Mounting: Install commercial, electric, domestic-water heaters on concrete base. Comply with requirements for concrete bases specified in Section 03 30 53 "Miscellaneous Cast-in-Place Concrete."
 - 1. Exception: Omit concrete bases for commercial, electric, domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
 - 2. Maintain manufacturer's recommended clearances.
 - 3. Arrange units so controls and devices that require servicing are accessible.
 - 4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
 - 5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

7. Install anchor bolts to elevations required for proper attachment to supported equipment.
 8. Anchor domestic-water heaters to substrate.
- B. Install electric, domestic-water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 22 05 23 "General-Duty Valves for Plumbing Piping."
- C. Install commercial, electric, domestic-water heaters with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Section 22 05 48 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- D. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- E. Install combination temperature-and-pressure relief valves in water piping for electric, domestic-water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- F. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for electric, domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Section 22 11 19 "Domestic Water Piping Specialties."
- G. Install thermometers on outlet piping of electric, domestic-water heaters. Comply with requirements for thermometers specified in Section 22 05 19 "Meters and Gages for Plumbing Piping."
- H. Install thermometers on inlet and outlet piping of domestic-water heaters. Comply with requirements for thermometers specified in Section 22 05 19 "Meters and Gages for Plumbing Piping."

- I. Assemble and install inlet and outlet piping manifold kits for multiple electric, domestic-water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each electric, domestic-water heater. Include shutoff valve and thermometer in each domestic-water heater inlet and outlet, and throttling valve in each electric, domestic-water heater outlet. Comply with requirements for valves specified in Section 22 05 23 "General-Duty Valves for Plumbing Piping," and comply with requirements for thermometers specified in Section 22 05 19 "Meters and Gages for Plumbing Piping."
- J. Install pressure-reducing valve with integral bypass relief valve in electric, domestic-water booster-heater inlet piping and water hammer arrester in booster-heater outlet piping. Set pressure-reducing valve for outlet pressure of 25 psig. Comply with requirements for pressure-reducing valves and water hammer arresters specified in Section 22 11 19 "Domestic Water Piping Specialties."
- K. Install piping-type heat traps on inlet and outlet piping of electric, domestic-water heater storage tanks without integral or fitting-type heat traps.
- L. Fill electric, domestic-water heaters with water.
- M. Charge domestic-water compression tanks with air.

3.2 CONNECTIONS

- A. Comply with requirements for piping specified in Section 22 11 16 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to electric, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

3.4 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.
 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 operation.
 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections. Comply with requirements in Section 01 40 00 "Quality Requirements" for retesting and reinspecting requirements and Section 01 73 00 "Execution" for requirements for correcting the Work.
- C. Prepare test and inspection reports.

3.5 DEMONSTRATION

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

END OF SECTION

SECTION 22 40 00

PLUMBING FIXTURES

(Part of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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 includes the following conventional plumbing fixtures and related components
 - 1. Fixture supports.
 - 2. Water closets.
 - 3. Flushometers.
 - 4. Toilet seats.
 - 5. Urinals.
 - 6. Lavatories.
 - 7. Faucets for lavatories
 - 8. Protective shielding guards.
 - 9. Commercial sinks.
 - 10. Sink faucets

11. Service sinks.
 12. Drinking Fountains (electric water coolers) and bottle filters
 13. Shower heads and Shower Valves.
- B. This Section includes the following emergency plumbing fixtures and related components:
1. Eyewash equipment.
- C. Related Sections include the following:
1. Division 10 Section "Toilet Accessories."
 2. Division 22 Section "Domestic Water Piping Specialties" for backflow preventers, floor drains, and specialty fixtures not included in this Section.

1.3 SUBMITTALS

- A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.
- D. Warranty: Special warranty specified in this Section.
- E. Furnish extra materials that match DRINKING FOUNTAIN products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Filter Cartridges: Equal to 10 percent of quantity installed for each type and size indicated, but no fewer than 5 of each.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.
 - 1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 101-336, "Americans with Disabilities Act" and California Access Compliance Reference Manual for plumbing fixtures for people with disabilities.
- D. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.
- E. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.
- F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.
- G. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
 - 1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
 - 2. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
 - 3. Solid-Surface-Material Lavatories and Sinks: ANSI/ICPA SS-1.
 - 4. Stainless-Steel Residential Sinks: ASME A112.19.3.
 - 5. Vitreous-China Fixtures: ASME A112.19.2M.
 - 6. Water-Closet, Flush Valve, Tank Trim: ASME A112.19.5.

- H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
 - 1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
 - 2. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
 - 3. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
 - 4. Faucets: ASME A112.18.1.
 - 5. Hose-Connection Vacuum Breakers: ASSE 1011.
 - 6. Hose-Coupling Threads: ASME B1.20.7.
 - 7. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
 - 8. NSF Potable-Water Materials: NSF 61.
 - 9. Pipe Threads: ASME B1.20.1.
 - 10. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
 - 11. Supply Fittings: ASME A112.18.1.
 - 12. Brass Waste Fittings: ASME A112.18.2.
- I. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:
 - 1. Atmospheric Vacuum Breakers: ASSE 1001.
 - 2. Brass and Copper Supplies: ASME A112.18.1.
 - 3. Brass Waste Fittings: ASME A112.18.2.
 - 4. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.
- J. Comply with the following applicable standards and other requirements specified for miscellaneous components:
 - 1. ASSE 1008 and UL 430.

2. Air-Gap Fittings: ASSE 1021.
 3. Flexible Water Connectors: ASME A112.18.6.
 4. Floor Drains: ASME A112.6.3.
 5. Hose-Coupling Threads: ASME B1.20.7.
 6. Hot-Water Dispensers: ASSE 1023 and UL 499.
 7. Off-Floor Fixture Supports: ASME A112.6.1M.
 8. Pipe Threads: ASME B1.20.1.
 9. Plastic Toilet Seats: ANSI Z124.5.
 10. Supply and Drain Protective Shielding Guards: ICC A117.1.
- K. ANSI Standard: Comply with ANSI Z358.1, "Emergency Eyewash and Shower Equipment."
- L. NSF Standard: Comply with NSF 61, "Drinking Water System Components - Health Effects," for fixture materials that will be in contact with potable water. Retain paragraph below if fixtures include accessible emergency plumbing fixtures. There are similar Federal Government standards for accessibility; verify requirements with authorities having jurisdiction.
- M. Regulatory Requirements: Comply with requirements in ICC/ANSI A117.1, "Accessible and Usable Buildings and Facilities"; "Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.
- N. LEED Submittals:
1. Product Data: Documentation indicating that flow and water consumption requirements comply with Prerequisite WE 1, Credit WE 2, and Credit WE 3.

PART 2 - PRODUCTS

2.1 FIXTURE SUPPORTS

A. Manufacturers:

- a. Josam Company.
- b. Smith, Jay R. Mfg. Co.
- c. Tyler Pipe; Wade Div.
- d. Zurn Plumbing Products Group; Specification Drainage Operation.

B. Water-Closet Supports:

1. Description: Combination carrier designed for accessible or standard mounting height of wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

C. Lavatory Supports:

1. Description: Type II, lavatory carrier with concealed arms and tie rod for wall-mounting, lavatory-type fixture. Include steel uprights with feet.
2. Accessible-Fixture Support: Include rectangular steel uprights.

2.2 WATER CLOSETS

A. Water Closets:

1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. American Standard Companies, Inc.
 - b. Kohler Co.
 - c. Sloan

2. Description: Wall-mounting, back-outlet, top spud, vitreous-china fixture designed for flushometer valve operation.
 - a. Type: Siphon jet.
 - b. Strainer or Trapway: With integral trap.
 - c. Design Consumption: 1.28 gal/flush in public spaces
 - d. Color: White.
 - e. Supply Spud Size: NPS 1-1/2.
 - f. Outlet Size: NPS 4.

2.3 WATER CLOSET FLUSHOMETERS

A. Flushometers:

1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. American Standard Companies, Inc.
 - b. Sloan Valve Company.
 - c. Toto
2. Description: top spud flushometer valve operation with sensor hardwired.
 - a. Type: Siphon jet.
 - b. Design Consumption: 1.28 gal/flush in public spaces
 - c. Color: Polished Chrome Finish.
 - d. Electrical Characteristics:
 - 1) Volts: 24Vac.
 - e. Sensor Range: 22"-42"
 - f. Self-Adaptive Window: +/-10"

2.4 TOILET SEATS

A. Toilet Seats:

1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Bemis Manufacturing Company.
 - b. Church Seats.
 - c. Kohler Co.
2. Description: Toilet seat for water-closet-type fixture.
 - a. Material: Molded, solid plastic.
 - b. Configuration: Open front without cover.
 - c. Size: Elongated.
 - d. Hinge Type: SC, self-sustaining, check.
 - e. Class: Heavy-duty commercial.
 - f. Color: White.

2.5 URINALS AND URINAL FLUSHOMETERS

A. Urinals:

1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Kohler Co.
 - b. Zurn
 - c. Sloan
2. Description: Wall-mounting, back-outlet, vitreous-china fixture designed for flushometer valve operation.
 - a. Type: Siphon jet.
 - b. Strainer or Trapway: With integral trap.
 - c. Design Consumption: 0.125 gal/flush in public spaces and 0.5 gal./flush in residential spaces – refer to plumbing plans for location
 - d. Color: White.

- e. Supply Spud Size: NPS 3/4.
- f. Outlet Size: NPS 2.

2.6 LAVATORIES

A. Lavatories, Wall hung:

1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. American Standard Companies, Inc.
 - b. Sloan
 - c. TOTO USA, Inc.
2. Description: Undermount China Rectangular, vitreous-china fixture.

2.7 LAVATORY FAUCETS

A. Lavatory Faucets:

1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. American Standard Companies, Inc.
 - b. Sloan Valve Company.
 - c. Toto
2. Description: Sensor faucet with multi-laminar spray and infrared sensor, battery powered.
 - a. Finish: Brushed stainless finish
 - b. Design Consumption: 0.5 gpm in public spaces and 1.0 gpm in residential spaces – refer to plumbing drawings for more information.

2.8 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. McGuire Manufacturing Co., Inc.
 - b. Plumberex Specialty Products Inc.
 - c. TRUEBRO, Inc.
2. Description: Manufactured plastic wraps for covering plumbing fixture hot-water supply and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

2.9 COMMERCIAL SINKS

A. Commercial Sinks:

1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Elkay Manufacturing Co.
 - b. American Standard
 - c. Kohler
2. Description: Stainless steel, undermount rectangular single bowl sink.

2.10 SINK FAUCETS

A. Sink Faucets:

1. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. American Standard Companies, Inc.
 - b. Elkay Manufacturing Co.

- c. Kohler Co.
- 2. Description: Gooseneck and pull down, multi-spray kitchen faucet, lever handle
 - a. Finish: Lustrous Steel
 - b. Design Consumption: 1.5 gpm

2.11 SERVICE SINKS

- A. Service Basins:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Fiat
 - b. Florestone Products Co., Inc.
 - c. Stern-Williams Co., Inc.
- 2. Description: Flush-to-wall, floor-mounting, precast terrazzo fixture with rim guard.

2.12 DRINKING FOUNTAINS AND BOTTLE FILLING STATIONS

- 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Elkay Manufacturing Co.
 - b. Halsey Taylor.
 - c. Tri Palm International, LLC; Oasis Brand.
- 2. Standards:
 - a. Comply with NSF 61.
 - b. Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant unless otherwise indicated.
- 3. Cabinet: All stainless steel.

4. Bubbler: One, with adjustable stream regulator, located on deck.
5. Control: Push button.
6. Drain: Grid with NPS 1-1/4 tailpiece.
7. Supply: NPS 3/8 with shutoff valve.
8. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 brass P-trap.
9. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards, with capacity sized for unit peak flow rate.
10. Cooling System: Electric, hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
 - 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.
11. Capacities and Characteristics:
 - a. Cooled Water: 12 gph.
 - b. Ambient-Air Temperature: 90 deg F.
 - c. Inlet-Water Temperature: 80 deg F (27 deg C).
 - d. Cooled-Water Temperature: 50 deg F (10 deg C).
 - e. Electrical Characteristics:
 - 1) Motor Horsepower: 1/4.
 - 2) Volts: 120-V ac.
 - 3) Phase: Single.
 - 4) Hertz: 60.

2.13 SHOWER HEADS AND SHOWER VALVES

- A. Shower Head with Single-Handle, Pressure-Balanced Mixing Valve:
 1. Basis of Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

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- a. Delta
 - b. Symmons
 - c. American Standard
- 2. Source Limitations: Obtain shower heads and shower valves from single source from single manufacturer.
 - 3. Description: Single-handle, pressure-balance mixing valve with hot- and cold-water indicators; check stops; and shower head.
 - 4. Shower Valve:
 - a. Standards: ASME A112.18.1/CSA B125.1 and ASSE 1016/ASME A112.1016/CSA B125.16.
 - b. Body Material: Solid brass.
 - c. Finish: Polished chrome plate
 - d. Mounting: Exposed.
 - e. Operation: Single-handle, twist or rotate control.
 - f. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.
 - 5. Supply Connections: NPS 1/2 (DN 15).
 - 6. Shower Head:
 - a. Standard: ASME A112.18.1/CSA B125.1.
 - b. EPA WaterSense: Required.
 - c. Shower Head Maximum Flow Rate: per equipment schedules
 - d. Shower Head Material: Metallic with chrome-plated finish.
 - e. Integral Volume Control: Required.
- B. Decon area showers
- 1. Basis of Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Willoughby
 - b. Metcraft Industries
 - c. Acorn
 - 2. Stainless steel panel with integral control valve and shower head, no soap holder.

2.14 EYEWASH EQUIPMENT

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on plumbing schedule on the drawings or comparable product matching the performance by one of the following:
 - a. Guardian.
 - b. Haws
 - c. Speakman

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 cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.
- B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
 1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
 2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
 3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.

- C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.
- D. Install wall-mounting fixtures with tubular waste piping attached to supports.
- E. Install counter-mounting fixtures in and attached to casework.
- F. Install fixtures level and plumb according to roughing-in drawings.
- G. 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, gate, or globe valves if supply stops are not specified with fixture. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
- H. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.
- I. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.
- J. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.
- K. Install toilet seats on water closets.
- L. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
- M. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.
- N. 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.
- O. Install traps on fixture outlets.

1. Exception: Omit trap on fixtures with integral traps.
 2. Exception: Omit trap on indirect wastes, unless otherwise indicated.
- P. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Common Work Results for Plumbing."
- Q. Set bathtubs and service basins in leveling bed of cement grout. Grout is specified in Division 22 Section "Common Work Results for Plumbing."
- R. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."
- S. Install laminar-flow, faucet-spout fittings in faucet spouts where laminar-flow fittings are specified.
- T. Set freestanding pressure water coolers on floor.
- U. Install thermometers in supply and outlet piping connections to water-tempering equipment for all emergency fixtures. Comply with requirements for thermometers specified in Division 22 Section "Meters and Gages for Plumbing Piping."
- V. Fill self-contained fixtures with flushing fluid.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

- E. 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 Division 22 Section "Domestic Water Piping."
- F. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary waste and vent piping. Comply with requirements for waste piping specified in Division 22 Section "Sanitary Waste and Vent Piping."
- G. Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to sanitary waste or storm drainage piping.
- H. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.4 FIELD QUALITY CONTROL

- A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.
- B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.
- C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.
- D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.
- E. Install fresh batteries in sensor-operated mechanisms.
- F. Emergency plumbing fixtures and water-tempering equipment will be considered defective if they do not pass tests and inspections.

3.5 ADJUSTING

- A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

- B. Operate and adjust disposers, hot-water dispensers and controls. Replace damaged and malfunctioning units and controls.
- C. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.
- D. Replace washers and seals of leaking and dripping faucets and stops.
- E. Install fresh batteries in sensor-operated mechanisms.
- F. Adjust fixture flow regulators for proper flow and stream height.
- G. Adjust pressure water-cooler temperature settings.
- H. Adjust or replace fixture flow regulators for proper flow.
- I. Adjust equipment temperature settings.

3.6 CLEANING

- A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:
 - 1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
 - 2. Remove sediment and debris from drains.
- B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.7 PROTECTION

- A. Provide protective covering for installed fixtures and fittings.
- B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION

SECTION 22 61 13

COMPRESSED-AIR PIPING

(Part of Work of Section 22 00 01 – PLUMBING, Trade Bid Required)

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 includes the following:
 - 1. Compressed-air piping and specialties for nonmedical laboratory facilities, designated "laboratory air," operating at 125 psig.

1.3 DEFINITIONS

- A. 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.

1.4 SUBMITTALS

- A. Product Data: For the following:
 - 1. Compressed-air tubes and fittings.
- B. Qualification Data: For Installer and testing agency.
- C. Brazing certificates.
- D. Field quality-control test reports.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum piping testing indicated, that is acceptable to authorities having jurisdiction.

1. Qualify testing personnel according to ASSE Standard #6020 for inspectors and ASSE Standard #6030 for verifiers.
- B. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications," or AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. ASME Compliance:
 1. Comply with ASME B31.1, "Power Piping," for laboratory compressed-air piping operating at more than 150 psig.
 2. Comply with ASME B31.9, "Building Services Piping," for laboratory compressed-air piping operating at 150 psig or less.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

- A. Copper Medical Gas Tube: ASTM B 819, Types K and L, seamless, drawn temper that has been manufacturer cleaned, purged, and sealed for medical gas service. Include standard color marking "OXY," "MED," "OXY/MED," "OXY/ACR," or "ACR/MED" in green for Type K tube and in blue for Type L tube.
 1. General Requirements for Copper Fittings: Manufacturer cleaned, purged, and bagged for oxygen service according to CGA G-4.1.
 2. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, with dimensions for brazed joints.
 3. Copper Unions: ASME B16.22 or MSS SP-123, wrought copper or cast-copper alloy.
- B. Copper Water Tube: ASTM B 88, Type M (ASTM B 88M, Type C), seamless, drawn temper.
 1. Copper Fittings: ASME B16.18, cast-copper or ASME B16.22, wrought-copper, solder-joint pressure type.

2.2 JOINING MATERIALS

- A. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.3 VALVES

- A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.
- B. Ball Valves: MSS SP-110, 3-piece body, brass or bronze.
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Allied Healthcare Products, Inc.; Chemetron Div.
 - b. Allied Healthcare Products, Inc.; Oxequip Health Industries.
 - c. Amico Corporation.
 - d. BeaconMedaes.
 - e. Conbraco Industries, Inc.
 - f. NIBCO INC.
 - g. Squire-Cogswell/Aeros Instruments, Inc.
 - h. Tri-Tech Medical.
 - 2. Pressure Rating: 300 psig minimum.
 - 3. Ball: Full-port, chrome-plated brass.
 - 4. Seats: PTFE or TFE.
 - 5. Handle: Lever type with locking device.
 - 6. Stem: Blowout proof with PTFE or TFE seal.
 - 7. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
- C. Check Valves: In-line pattern, bronze.
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Allied Healthcare Products, Inc.; Chemetron Div.
 - b. Amico Corporation.
 - c. BeaconMedaes.
 - d. Conbraco Industries, Inc.
 - e. Squire-Cogswell/Aeros Instruments, Inc.
 - f. Tri-Tech Medical.
 - 2. Pressure Rating: 300 psig minimum.
 - 3. Operation: Spring loaded.
 - 4. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
- D. Safety Valves: Bronze-body, ASME-construction, poppet, pressure-relief type with settings to match system requirements.
- E. Automatic Drain Valves: Stainless-steel body and internal parts, rated for 200-psig minimum working pressure, capable of automatic discharge of collected condensate. Include mounting bracket where wall mounting is indicated.

2.4 FLEXIBLE PIPE CONNECTORS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Flex-Hose Co., Inc.
 - 2. Flexicraft Industries.
 - 3. Hyspan Precision Products, Inc.
 - 4. Mercer Rubber Co.
 - 5. Metraflex, Inc.
 - 6. Proco Products, Inc.
 - 7. Unaflex.
 - 8. Universal Metal Hose; a Hyspan Co.
- B. Description: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
 - 1. Working-Pressure Rating: 200 psig minimum.
 - 2. End Connections: Threaded copper pipe or plain-end copper tube.

2.5 SLEEVES

- A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
- B. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with set screws.

2.6 ESCUTCHEONS

- A. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to closely fit around pipe and tube and OD that completely covers opening.
- B. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.
- C. One-Piece, Cast-Brass Escutcheons: With set screw.
 - 1. Finish: Polished chrome-plated and rough brass.
- D. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
 - 1. Finish: Polished chrome-plated and rough brass.
- E. One-Piece, Stamped-Steel Escutcheons: With set screw or spring clips and chrome-plated finish.

- F. Split-Plate, Stamped-Steel Escutcheons: With set screw or spring clips and chrome-plated finish.
- G. One-Piece, Floor-Plate Escutcheons: Cast iron.
- H. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.
- I. Chrome plated plastic escutcheons are not acceptable.

2.7 GROUT

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - 1. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - 2. Design Mix: 5000-psi 28-day compressive strength.
 - 3. Packaging: Premixed and factory packaged.

2.8 NITROGEN

- A. Description: Comply with USP 28 - NF 23 for oil-free dry nitrogen.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Cleaning of Gas Tubing: If manufacturer-cleaned and -capped fittings or tubing are not available or if precleaned fittings or tubing must be recleaned because of exposure, have supplier or separate agency acceptable to authorities having jurisdiction perform the following procedures:
 - 1. Clean gas tube and fittings, valves, gages, and other components of oil, grease, and other readily oxidizable materials as required for oxygen service according to CGA G-4.1, "Cleaning Equipment for Oxygen Service."
 - 2. Wash gas tubing and components in hot, alkaline-cleaner-water solution of sodium carbonate or trisodium phosphate in proportion of 1 lb of chemical to 3 gal. of water.
 - a. Scrub to ensure complete cleaning.
 - b. Rinse with clean, hot water to remove cleaning solution.

3.2 PIPING APPLICATIONS

- A. Compressed Air Piping: Use the following piping materials for each size range:

1. NPS 4 and Smaller: Type L, copper medical gas tube; wrought-copper fittings; and brazed joints.
- B. Drain Piping: Use one of the following piping materials:
 1. Copper water tube, cast- or wrought-copper fittings, and soldered joints.

3.3 PIPING INSTALLATION

- A. 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. Comply with ASSE Standard #6010 for installation of compressed-air 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 air and drain 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 system pressure rating used in applications below unless otherwise indicated.
- I. Install eccentric reducers, if available, where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.
- J. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.
- K. Install thermometer and pressure gauge on discharge piping from each air compressor and on each receiver. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping."
- L. Install piping to permit valve servicing.
- M. Install piping free of sags and bends.

- N. Install fittings for changes in direction and branch connections.
- O. Install seismic restraints on compressed-air piping. Seismic-restraint devices are specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- P. Install compressed-air service connections recessed in walls. Attach roughing-in assembly to substrate; attach finishing assembly to roughing-in assembly.
- Q. Connect compressed-air piping to air compressors (or as described in the drawings), and to compressed-air outlets and equipment requiring compressed-air service.
- R. Install unions in copper compressed-air tubing adjacent to each valve and at final connection to each piece of equipment, machine, and specialty.

3.4 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 pressure regulators on compressed-air piping where reduced pressure is required.
- D. Install automatic drain valves on equipment, specialties, and piping with drain connection. Run drain piping to floor drain so contents spill over or into it.
- E. Install flexible pipe connectors in discharge piping and in inlet air piping from remote air-inlet filter of each air compressor.

3.5 JOINT CONSTRUCTION

- A. Remove scale, slag, dirt, and debris from outside of cleaned tubing and fittings before assembly.
- B. Braze Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Braze Joints" Chapter. Continuously purge joint with oil-free dry nitrogen during brazing.

3.6 SLEEVE INSTALLATION

- A. Sleeves are not required for core-drilled holes.
- B. Permanent sleeves are not required for holes formed by removable PE sleeves.

- C. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs using galvanized-steel pipe.
 - 1. Wall Penetrations: Cut sleeves to length for mounting flush with both surfaces.
 - 2. Floor Penetrations: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
- D. Install sleeves in new walls and slabs as new walls and slabs are constructed.
- E. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - 1. Steel Pipe Sleeves: For pipes smaller than NPS 6.
 - 2. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Comply with requirements in Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
 - a. Seal space outside of sleeve fittings with grout.
- F. 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 in Division 07 Section "Penetration Firestopping."

3.7 ESCUTCHEON INSTALLATION

- A. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 - 1. New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
 - b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.
 - c. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.
 - d. Bare Piping in Unfinished Service Spaces: One piece, stamped steel with set screw or spring clips.
 - e. Bare Piping in Equipment Rooms: One piece, stamped steel with set screw or spring clips.
 - f. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.
 - g. Chrome plated plastic escutcheons are not acceptable.

3.8 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.
- B. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.
- C. Vertical Piping: MSS Type 8 or 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 Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.
- F. Base of Vertical Piping: MSS Type 52, spring hangers.
- G. Support horizontal piping within 12 inches of each fitting and coupling.
- H. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.
- I. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1/4: 60 inches with 3/8-inch rod.
 - 2. NPS 3/8 and NPS 1/2: 72 inches with 3/8-inch rod.
 - 3. NPS 3/4: 84 inches with 3/8-inch rod.
 - 4. NPS 1: 96 inches with 3/8-inch rod.
 - 5. NPS 1-1/4: 108 inches with 3/8-inch rod.
 - 6. NPS 1-1/2: 10 feet with 3/8-inch rod.
 - 7. NPS 2: 11 feet with 3/8-inch rod.
- J. Install supports for vertical copper tubing every 10 feet.

3.9 LABELING AND IDENTIFICATION

- A. Install identifying labels and devices for non-medical laboratory compressed-air piping, valves, and specialties. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.10 FIELD QUALITY CONTROL FOR COMPRESSED-AIR PIPING IN NON-MEDICAL LABORATORY FACILITIES

- A. Testing Agency Engage qualified testing agency to perform field tests and inspections of compressed-air piping in nonmedical laboratory facilities and prepare test reports.
- B. Perform tests and inspections of compressed-air piping in nonmedical laboratory facilities and prepare test reports.
- C. Tests and Inspections:
 - 1. Piping Leak Tests for Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill general-service 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.
 - 3. Inspect filters and pressure regulators for proper operation.

3.11 DEMONSTRATION

- A. Engage factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain compressed-air alarm systems. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

SECTION 23 00 01
HEATING, VENTILATING AND AIR CONDITIONING
(Trade Bid Required)

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 the Specifications.
- B. Time, Manner and Requirements for Submitting Trade Bids:
 - 1. Trade bids for work under this Section shall be for the complete work and shall be filed in a sealed envelope with the Owner at a time and place as stipulated in the "INSTRUCTIONS TO BIDDERS".
 - a. The following should appear on the upper left hand corner of the envelope:
 - b. NAME OF TRADE BIDDER: (Insert name of trade bidder)
 - c. TRADE BID FOR SECTION: 23 00 01 – HEATING, VENTILATION, AND AIR CONDITIONING
 - d. Each trade bid submitted for work under this Section shall be on forms furnished by the Owner as required by Section 8 of Chapter 149A of the General Laws, as amended. Trade bid forms may be obtained at the office of the Owner.
 - 2. Trade bids filed with the Owner shall be accompanied by BID BOND or CASH or CERTIFIED CHECK or TREASURER'S CHECK or CASHIER'S CHECK issued by a responsible bank or trust company payable to the City of Worcester in the amount of five percent of the trade bid. A trade bid accompanied by any other form of bid deposit than those specified will be rejected.
- C. Trade Sub-Bid Requirements:
 - 1. Section 23 05 93 for testing, adjusting, and balancing.
 - 2. Section 23 31 13, Section 23 33 00, Section 23 33 46, Section 23 36 00, and Section 23 37 13 for sheetmetal work.
 - 3. Section 23 07 13, Section 23 07 16, and Section 23 07 19 for insulation work.
 - 4. Section 23 09 23 for temperature controls work.
- D. Reference Drawings: The Work of this Trade Bid is shown on the following Contract Drawings:
 - 1. 01-GENERAL Series
 - 2. 23-HVAC Series

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. All Work of the following sections:
 - a. 23-HEATING, VENTILATING AND AIR CONDITIONING sections
 2. Firestopping for the Work of this Section, including cutting penetrations and firestopping; complying with requirements specified in Section 07 84 13 - PENETRATION FIRESTOPPING.
 3. Core drilling for the Work of this Section.
 4. Certified seismic restraints to meet the Commonwealth of Massachusetts Building Code applicable at the time the building permit is issued.
 5. Coordination drawings and record drawings and similar requirements.
 6. CAMIS excel spreadsheet data collection for Equipment Template and PM Procedure tabs as described in Section 01 77 00 - CLOSEOUT PROCEDURES
 7. BIM modeling as specified in this Section and in Section 01 31 29 - COORDINATION DRAWINGS.
- B. Alternates: Not Applicable.
- C. Items to Be Installed Only: Install the following items as furnished by the designated Sections:
1. Section 26 00 01 - ELECTRICAL WORK
 - a. Duct mounted smoke detectors.
 - b. Emergency generator access.
- D. Items to Be Furnished Only: Furnish the following items for installation by the designated Sections:
1. Section 03 30 00 - CAST-IN-PLACE CONCRETE:
 - a. Pipe and duct sleeves for placement into formwork.
 2. Section 04 20 00 - UNIT MASONRY:
 - a. Access doors in masonry openings.
 - b. Pipe and duct sleeves for placement into masonry openings.
 3. Section 07 00 01 - ROOFING AND FLASHING:
 - a. Roof curbs.
 4. Section 09 29 00 - GYPSUM BOARD ASSEMBLIES:
 - a. Access doors in gypsum board openings.
 - b. Pipe and duct sleeves for placement into gypsum board openings.
 - c. Pipe and duct sleeves for placement into gypsum board shaft-wall openings.
 5. Section 09 30 13 - TILING:
 - a. Access doors in tile.
 6. Section 09 51 13 - ACOUSTICAL PANEL CEILINGS:
 - a. Access doors in acoustical tile.
 7. Section 26 00 01 - ELECTRICAL WORK:
 - a. Magnetic starters.
 - b. DDC control panels.

- E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
1. Section 03 30 00 - CAST-IN-PLACE CONCRETE for cutting and patching of concrete walls and for concrete equipment pads, manhole and thrust block requirements.
 2. Section 05 12 00 - STRUCTURAL STEEL FRAMING for structural supports necessary to distribute loading from equipment to roof or floor.
 3. Section 07 00 01 - ROOFING AND FLASHING for flashing of roof mounted equipment and roofing penetrations.
 4. Section 07 84 13 - PENETRATION FIRESTOPPING for coordination of floor and wall penetrations with firestopping contractor.
 5. Section 09 29 00 - GYPSUM BOARD for coordination with gypsum ceilings and walls.
 6. Section 09 51 13 - ACOUSTICAL PANEL CEILINGS for coordination with acoustical ceilings.
 7. Section 22 00 01 - PLUMBING for cold water make-up to mechanical equipment as indicated on the Drawings.
 8. Section 26 00 01 - ELECTRICAL WORK for electrical power to mechanical equipment as indicated on the Drawings.
 9. Section 31 20 00 - EARTH MOVING for excavation and backfilling
- F. Perform work and provide material and equipment as shown on Drawings and as specified or indicated in this Section of the Specifications. Completely coordinate work of this Section with work of other trades and provide a complete and fully functional installation.
- G. Give notices, file plans, obtain permits and licenses, pay fees and back charges, and obtain necessary approvals from authorities that have jurisdiction as required to perform work in accordance with all legal requirements and with Specifications, Drawings, Addenda and Change Orders, all of which are part of Contract Documents.

END OF SECTION

SECTION 23 05 00

COMMON WORK RESULTS FOR HVAC

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

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. Where conflicts occur between divisions, the more stringent requirement shall apply.
- B. Related Sections:
 - 1. All sections within Division 23 – Heating, Ventilating, and Air Conditioning.
 - 2. All sections within Division 25 – Controls.
 - 3. All sections within Division 01 – General Requirements.
 - 4. Relevant sections within Division 03 – Concrete.
 - a. Section 03 10 00 – Concrete Forming and Accessories.
 - b. Section 03 30 00 – Cast-In-Place Concrete.
 - c. Section 03 37 13 – Shotcrete.
 - d. Section 03 38 00 – Post-Tensioned Concrete.
 - 5. Relevant sections within Division 05 – Metals.
 - a. Section 05 12 00 – Structural Steel Framing.
 - b. Section 05 31 00 – Steel Decking.
 - c. Section 05 50 13 – Metal Service Platforms.
 - 6. Relevant sections within Division 07 – Thermal and Moisture Protection.
 - a. Section 07 21 00 – Thermal Insulation.
 - b. Section 07 62 00 – Sheet Metal.
 - c. Section 07 84 00 – Fire Stopping.
 - d. Section 07 86 00 – Smoke Seals.

7. Relevant sections within Division 08 – Openings.
 - a. Section 08 10 00 – Doors and Frames.
 - b. Section 08 31 13 – Access Doors and Frames.
 - c. Section 08 71 00 – Door Hardware.
 - d. Section 08 90 00 – Louvers and Vents.
8. Relevant Sections within Division 09.
 - a. Section 09 90 00 – Painting and Coating.
 - b. Section 09 29 00 – Gypsum Board.
9. Relevant sections within Division 11 – Equipment.
 - a. Section 11 40 00 – Food Service Equipment.
 - b. Section 11 53 00 – Laboratory Equipment.
10. Relevant sections within Division 21 – Fire Protection Systems.
 - a. Section 21 12 00 – Fire Suppression Standpipe Systems.
 - b. Section 21 13 00 – Fire Suppression Sprinkler Systems.
 - c. Section 22 22 00 – Gaseous Agent Suppression Systems.
 - d. Section 22 30 00 – Fire Pumps.
11. Relevant sections within Division 22 – Plumbing.
 - a. Section 22 10 00 – Plumbing Pumps.
 - b. Section 22 30 00 – Plumbing Equipment.
 - c. Section 22 60 00 – Mechanical Gas Systems.
 - d. Section 22 05 03 – Pipes and Tubes for Plumbing Piping and Equipment.
12. Relevant sections within Division 26 – Electrical.
 - a. Section 26 05 03 – Equipment Wiring Connections.
 - b. Section 26 05 26 – Grounding and Bonding for Electrical Systems.
 - c. Section 26 24 19 – Motor Control Centers.
 - d. Section 26 05 19 – Low Voltage Electrical Power Conductors and Cables.
 - e. Section 26 22 00 – Low Voltage Transformers.
13. Relevant sections within Division 28 - Electronic Safety and Security.
 - a. Section 28 31 00 – Fire Detection and Alarm.

1.2 SUMMARY

A. Section Includes:

1. Thermometers, liquid in glass.
2. Duct-thermometer mounting brackets.
3. Thermowells.
4. Pressure gauges, dial type.
5. Gauge attachments.
6. Test plugs.
7. Test-plug kits.

B. Related Requirements:

1. Section 23 21 16 "Hydronic Piping Specialties" for condensate meters.
2. Section 23 09 23.13 "Energy Meters" for thermal-energy meters connecting with the DDC system.
3. Section 23 09 23.14 "Flow Instruments" for primary flow instruments connecting with the DDC system.

1.3 ACTION SUBMITTALS

A. Product Data:

1. For each type of product, excluding motors which are included in Part 1 of HVAC equipment Sections.
 - a. Include construction details, material descriptions, and dimensions of individual components, and finishes.
 - b. Include operating characteristics and furnished accessories.

B. Delegated Design Submittals: 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. Product Certificates: For each type of meter.
- B. Welding certificates.
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of expansion joint, meter, and gauge to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M.
- B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators in accordance with 2021 ASME Boiler and Pressure Vessel Code, Section IX.

1.7 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 METERS AND GAUGES FOR HVAC PIPING

A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Flo Fab Inc.
 - b. Miljoco Corporation.
 - c. Palmer Wahl Instrumentation Group.
 - d. Tel-Tru Manufacturing Company.
 - e. Terice, H. O. Co.
 - f. Weiss Instruments, Inc.
 - g. Winters Instruments - U.S.
 - h. Or Approved Equal.
2. Standard: ASME B40.200.
3. Case: Cast aluminum; 9-inch (229-mm) nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C).
7. Window: Glass or plastic.
8. Stem: Aluminum and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
9. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.2 Plastic-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Flo Fab Inc.
 - b. Miljoco Corporation.
 - c. Palmer Wahl Instrumentation Group.
 - d. Tel-Tru Manufacturing Company.
 - e. Terice, H. O. Co.

- f. Weiss Instruments, Inc.
 - g. Winters Instruments - U.S.
 - h. Or Approved Equal.
- 2. Standard: ASME B40.200.
- 3. Case: Plastic; 7-inch (178-mm) nominal size unless otherwise indicated.
- 4. Case Form: Adjustable angle unless otherwise indicated.
- 5. Tube: Glass with magnifying lens and blue or red organic liquid.
- 6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C).
- 7. Window: Glass or plastic.
- 8. Stem: Aluminum and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
- 9. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
- 10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.
- 11. Accuracy: Plus or minus 2 deg F (1 deg C).

2.3 Duct-Thermometer Mounting Brackets:

- 1. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.4 Thermowells:

- 1. Standard: ASME B40.200.
- 2. Description: Pressure-tight, socket-type fitting made for insertion in piping tee fitting.
- 3. Material for Use with Copper Tubing: CNR or CUNI.
- 4. Material for Use with Steel Piping: CRES or CSA.
- 5. Type: Stepped shank unless straight or tapered shank is indicated.
- 6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads, to be coordinated with instrumentation to be installed.
- 7. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), with ASME B1.1 screw threads, to be coordinated with instrumentation to be installed.
- 8. Bore: Diameter required to match thermometer bulb or stem.
- 9. Insertion Length: Length required to match thermometer bulb or stem to be within center 1/3rd of pipe.

10. Lagging Extension: Include on thermowells for insulated piping and tubing; minimum 2-inches (50 mm) and greater to match installed insulation thickness plus 0.5 inches (13 mm).
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection. Match thermowell material.
12. Heat-Transfer Medium: Mixture of graphite and glycerin or powdered aluminum and silicone .

2.5 Pressure Gauges, Dial Type - Direct Mounted, Metal Case:

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

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. AMETEK, Inc.; U.S. Gauge.
 - b. Ashcroft Inc.
 - c. Ernst Flow Industries.
 - d. Flo Fab Inc.
 - e. Marsh Bellofram.
 - f. Miljoco Corporation.
 - g. Noshok.
 - h. Palmer Wahl Instrumentation Group.
 - i. REOTEMP Instrument Corporation.
 - j. Tel-Tru Manufacturing Company.
 - k. Trerice, H. O. Co.
 - l. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
 - m. Weiss Instruments, Inc.
 - n. WIKA Instrument Corporation - USA.
 - o. Winters Instruments - U.S.
 - p. Or Approved Equal.
2. Standard: ASME B40.100.
3. Case: Sealed type(s); cast aluminum or drawn steel; 4-1/2-inch (114-mm) nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 (DN 8), 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 (kPa).

8. Pointer: Dark-colored metal.
9. Window: Glass or plastic.
10. Ring: Stainless steel.
11. Accuracy:
 - a. ASME B40.1, Grade A, plus or minus 1.0 percent of middle 50 percent of scale range and not greater than 2.0 percent in the lower and upper 25-percent of scale range.
 - b. ASME B40.1, Grade 1A, plus or minus 1.0 percent of span over the entire range.

B. Gauge Attachments:

1. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.
2. Siphons: Loop-shaped section of stainless-steel pipe with NPS 1/4 or NPS 1/2 (DN 8 or DN 15) pipe threads.
3. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads.
4. Instrumentation Piping: Sch. 80 red brass for copper and chilled water piping all sizes, Sch. 80 seamless carbon steel for hot water piping NPS 2.5 inch and larger.

2.6 Test Plugs:

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Flow Design, Inc.
 - b. Miljoco Corporation.
 - c. National Meter, Inc.
 - d. Peterson Equipment Co., Inc.
 - e. Sisco Manufacturing Company, Inc.
 - f. Trerice, H. O. Co.
 - g. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
 - h. Weiss Instruments, Inc.
 - i. Or Approved Equal.
2. Source Limitations: Provide test plugs from single manufacturer.
3. Description: Test-station fitting made for insertion in piping tee fitting.

4. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping, minimum 2-inches (50 mm).
5. Thread Size: NPS 1/4 (DN 8) or NPS 1/2 (DN 15), ASME B1.20.1 pipe thread.
6. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F (3450 kPa at 93 deg C).
7. Core Inserts: EPDM self-sealing rubber.

2.7 Test-Plug Kits:

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Flow Design, Inc.
 - b. Miljoco Corporation.
 - c. National Meter, Inc.
 - d. Peterson Equipment Co., Inc.
 - e. Sisco Manufacturing Company, Inc.
 - f. Terice, H. O. Co.
 - g. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
 - h. Weiss Instruments, Inc.
2. Or Approved Equal.
3. Source Limitations: Provide test-plug kits from single manufacturer.
4. Furnish two (2) test-plug kits containing one thermometer, 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.
5. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F (minus 4 to plus 52 deg C).
6. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F (minus 18 to plus 104 deg C).
7. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch- (51- to 76-mm-) diameter dial and probe. Dial range shall be at least 0 to 200 psig (0 to 1380 kPa).
8. Carrying Case: Metal or plastic, with formed instrument padding.

PART 3 - EXECUTION

3.1 INSTALLATION OF METERS AND GAUGES

- A. Install thermowells with socket extending to center 1/3rd of pipe and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing, and support tubing to prevent kinks. Use minimum tubing length.
- G. Install pipe-mounted thermal-energy temperature sensors in thermowells and extend wiring to indicator.
- H. Install duct-thermometer-mounting brackets in walls of ducts. Attach to duct with screws.
- I. Install direct-mounted pressure gauges in piping tees with pressure gauge located on pipe at the most readable position.
- J. Install remote-mounted pressure gauges on panel.
- K. Install valve and snubber in piping for each pressure gauge for fluids (except steam).
- L. Install valve and syphon fitting in piping for each pressure gauge for steam.

- M. Install test plugs in piping tees.
- N. Install flow indicators in piping systems in accessible positions for easy viewing.
- O. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.
- P. Install flowmeter elements in accessible positions in piping systems.
- Q. Install wafer-orifice flowmeter elements between orifice-type pipe flanges.
- R. Install all flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.
- S. Install permanent indicators on walls or brackets in accessible and readable positions.
- T. Install connection fittings in accessible locations for attachment to portable indicators.
- U. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.
- V. Install thermometers in the following locations:
 - 1. Inlet and outlet of each hydronic zone.
 - 2. Inlet and outlet of each hydronic boiler where not part of the pre-purchased boiler package.
 - 3. Two inlets and two outlets of each chiller.
 - 4. Inlet and outlet of each hydronic coil in air-handling units.
 - 5. Two inlets and two outlets of each hydronic heat exchanger.
 - 6. Inlet and outlet of each air-source to water heat pump module.
 - 7. Inlet and outlet of each air-source to water heat pump bank.
 - 8. Inlet and outlet of each thermal-storage tank.
 - 9. Outside-, return-, supply-, and mixed-air ducts.
 - 10. Within 12 inches (300 mm) of any DDC controls temperature indicator.
- W. Install pressure gauges in the following locations:

1. Discharge of each pressure-reducing valve.
2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
3. Suction and discharge of each pump.
4. Within 12 inches (300 mm) of any DDC controls pressure indicator.

3.2 CONNECTIONS

- A. Install meters and gauges adjacent to machines and equipment to allow space for service and maintenance of meters, gauges, machines, and equipment.
- B. Connect flowmeter-system elements to meters.
- C. Connect flowmeter transmitters to meters.
- D. Connect thermal-energy meter transmitters to meters.

3.3 ADJUSTING

- A. After installation, calibrate meters according to manufacturer's written instructions.
- B. Adjust faces of meters and gauges to proper angle for best visibility.

3.4 FIELD QUALITY CONTROL

- A. Sleeves and Sleeve Seals:
 1. Perform the following tests and inspections:
 - a. 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.
 2. Prepare test and inspection reports.
- B. Escutcheons:

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

3.5 THERMOMETER APPLICATION

- A. Thermometers at inlet and outlet of each hydronic zone shall be the following:
 1. Compact Industrial-style, liquid-in-glass type.
- B. Thermometers at inlet and outlet of each hydronic boiler shall be the following:
 1. Compact Industrial-style, liquid-in-glass type.
- C. Thermometers at inlets and outlets of each chiller and air-source to water heat pump module, bank and mains, shall be the following:
 1. Compact Industrial-style, liquid-in-glass type.
- D. Thermometers at inlet and outlet of each hydronic coil in air-handling units shall be the following:
 1. Compact Industrial-style, liquid-in-glass type.
- E. Thermometers at inlets and outlets of each hydronic heat exchanger shall be the following:
 1. Compact Industrial-style, liquid-in-glass type.
- F. Thermometers at inlet and outlet of each hydronic heat-recovery unit shall be the following:
 1. Compact Industrial-style, liquid-in-glass type.
- G. Thermometers at inlet and outlet of each thermal-storage tank shall be the following:
 1. Compact Industrial-style, liquid-in-glass type.
- H. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be the following:

1. Compact Industrial-style, liquid-in-glass type.

3.6 THERMOMETER SCALE-RANGE APPLICATION

- A. Scale Range for Chilled-Water Piping: 0 to 120 deg F (Minus 20 to plus 50 deg C).
- B. Scale Range for Condenser-Water Piping: 0 to 160 deg F (Minus 20 to plus 50 deg C).
- C. Scale Range for Heating, Hot-Water Piping: 20 to 240 deg F (0 to 150 deg C).
- D. Scale Range for Outside Air: Minus 40 to plus 110 deg F (Minus 40 to plus 45 deg C).
- E. Scale Range for Return and Supply Air Ducts: 0 to 100 deg F (Minus 20 to plus 50 deg C).
- F. Scale Range for Air Ducts Downstream of Heating coils: 30 to 150 deg F (Minus 20 to plus 70 deg C).

3.7 PRESSURE-GAUGE APPLICATION

- A. Pressure gages at discharge of each pressure-reducing valve shall be the following:
 1. Sealed, direct-mounted, metal case. ASME B40.1, Grade 1A
- B. Pressure gages at inlet and outlet of each chiller chilled-water and condenser-water connection shall be the following:
 1. Sealed, direct-mounted, metal case. ASME B40.1, Grade 1A
- C. Pressure gages at suction and discharge of each pump shall be the following:
 1. Sealed, direct-mounted, metal case. ASME B40.1, Grade 1A
 2. Use compound gauge -30-in. Hg to +30 psi (minus 100 to 240kPa) on pump suctions, in addition to standard pressure gauges. Install in tee with isolation valve at same elevation as standard suction pressure gauge.

D. Pressure gages at air handling unit coils shall be the following:

1. Sealed, direct-mounted, metal case. ASME B40.1, Grade A

3.8 PRESSURE-GAUGE SCALE-RANGE APPLICATION

- A. Scale Range for Chilled-Water Piping: 0 to 100 psi (0 to 600 kPa).
- B. Scale Range for Condenser-Water Piping: 0 to 100 psi (0 to 600 kPa).
- C. Scale Range for Heating, Hot-Water Pump Suction Piping: 30-in. Hg to 30 psi (minus 100 to 240 kPa).
- D. Scale Range for Heating, Hot-Water Piping: 0 to 100 psi (0 to 600 kPa).

END OF SECTION

SECTION 23 05 23

GENERAL-DUTY VALVES FOR HVAC PIPING

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Angle valves.
2. Ball valves.
3. Check valves.
4. Air vents.
5. Drain valves.
6. Pressure and safety relief valves.
7. Chainwheels.

1.2 DEFINITIONS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene-propylene-diene monomer.
- C. FKM: Fluoroelastomer.
- D. NBR: Nitrile butadiene rubber (also known as "Buna-N").
- E. NRS: Nonrising stem.
- F. OS&Y: Outside screw and yoke.

- G. PTFE: Polytetrafluoroethylene.
- H. RPTFE: Reinforced polytetrafluoroethylene.
- I. RS: Rising stem.
- J. SWP: Steam working pressure.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include material descriptions and dimensions of individual components.
 - 2. Include operating characteristics and furnished accessories.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, grooved ends, press ends, solder ends, and weld ends.
 - 3. Set ball valves open to minimize exposure of functional surfaces.
 - 4. Set butterfly valves closed or slightly open.
 - 5. Block check valves in either closed or open position.
 - 6. Set gate valves closed to prevent rattling.
 - 7. Set plug valves to 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 or other components as lifting or rigging points unless specifically indicated for this purpose in manufacturer's written instructions.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

- A. Obtain each type of valve from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. 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 cast-copper solder-joint connections.
- 6. ASME B16.22 for wrought copper and copper-alloy solder-joint connections.
- 7. ASME B16.34 for flanged- and threaded-end connections.
- 8. ASME B16.51 for press joint connections.
- 9. ASME B31.1 for power piping valves.
- 10. ASME B31.9 for building services piping valves.

- B. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.

- C. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are unacceptable.

- D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

- E. Valve Sizes: Same as upstream piping unless otherwise indicated.

- F. Valve Bypass and Drain Connections: MSS SP-45.

- G. Valve Actuator Type:

- 1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
- 2. Handwheel: For valves other than quarter-turn types.
- 3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.

4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 plug valves, for each size square plug-valve head.
5. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

H. Valves in Insulated Piping:

1. Provide 2-inch (50-mm) extended neck stems.
2. Provide extended operating handles with nonthermal-conductive covering material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
3. Provide memory stops that are fully adjustable after insulation is applied.

2.3 ANGLE VALVES

A. Class 125 Bronze Angle Valves:

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. American Valve, Inc
 - b. Hammond Valve
 - c. Milwaukee Valve Company
 - d. NIBCO Inc.
 - e. Or approved equal
2. Description:
 - a. Standard: MSS SP-80, Type 1.
 - b. CWP Rating: 200 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - d. Ends: Threaded.
 - e. Stem and Disc: PTFE.
 - f. Packing: Asbestos free.
 - g. Handwheel: Malleable iron, bronze, or aluminum.

2.4 BALL VALVES

A. One-Piece Brass Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

GENERAL DUTY VALVES FOR HVAC PIPING

- a. Apollo Valves
 - b. KITZ Corporation
 - c. NIBCO
 - d. Or approved equal
 - 2. Description:
 - a. Standard: MSS SP-110.
 - b. CWP Rating: 400 psig.
 - c. Body Design: One piece.
 - d. Body Material: Forged brass.
 - e. Ends: Threaded.
 - f. Seats: PTFE.
 - g. Stem: Brass.
 - h. Ball: Chrome-plated brass.
 - i. Port: Reduced.
- B. Two-Piece Brass Ball Valves with Full Port and Brass Trim:
- 1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. American Valve, Inc
 - b. Apollo Valves
 - c. Watts; a Watts Water Technologies company
 - d. Or approved equal
 - 2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Two piece.
 - e. Body Material: Forged brass.
 - f. Ends: Threaded.
 - g. Seats: PTFE.
 - h. Stem: Brass.
 - i. Ball: Chrome-plated brass.
 - j. Port: Full.
- C. One-Piece Bronze Ball Valves with Bronze Trim:
- 1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Apollo Valves
 - b. NIBCO Inc.

- c. Watts; a Watts Water Technologies company
 - d. Or approved equal
 - 2. Description:
 - a. Standard: MSS SP-110.
 - b. CWP Rating: 400 psig.
 - c. Body Design: One piece.
 - d. Body Material: Bronze.
 - e. Ends: Threaded.
 - f. Seats: PTFE.
 - g. Stem: Bronze.
 - h. Ball: Chrome-plated brass.
 - i. Port: Reduced.
- D. Two-Piece Bronze Ball Valves with Full Port and Bronze or Brass Trim:
- 1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. American Valve
 - b. Apollo Valves
 - c. Crane; Crane Energy Flow Solutions
 - d. Jamesbury, Metso
 - e. Milwaukee Valve Company
 - f. NIBCO Inc.
 - g. Watts; a Watts Water Technologies company
 - h. Or approved equal
 - 2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Two piece.
 - e. Body Material: Bronze.
 - f. Ends: Threaded.
 - g. Seats: PTFE.
 - h. Stem: Bronze.
 - i. Ball: Chrome-plated brass.
 - j. Port: Full.
- E. Class 150 Steel Ball Valves with Full Port and Stainless-Steel Trim:
- 1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

- a. Apollo Valves
 - b. Jamesbury, Metso
 - c. NIBCO Inc.
 - d. Or approved equal
2. Description:
- a. Standard: MSS SP-72.
 - b. CWP Rating: 285 psig.
 - c. Body Design: Split body.
 - d. Body Material: Carbon steel, ASTM A 216, Type WCB.
 - e. Ends: Flanged.
 - f. Seats: PTFE.
 - g. Stem: Stainless steel.
 - h. Ball: Stainless steel, vented.
 - i. Port: Full.

2.5 CHECK VALVES

A. Class 125 Lift Check Valves with Nonmetallic Disc:

- 1. **Manufacturers:** Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. [Milwaukee Valve Company](#).
 - b. [NIBCO INC.](#)
 - c. [Watts Regulator Co.](#); a division of Watts Water Technologies, Inc.
 - d. Or Approved Equal.
- 2. Description:
 - a. Standard: MSS SP-80, Type 2.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Vertical flow.
 - d. Body Material: ASTM B 61 or ASTM B 62, bronze.
 - e. Ends: Threaded.
 - f. Disc: NBR or PTFE.

B. Class 125, Bronze Swing Check Valves with Nonmetallic Disc:

- 1. **Manufacturers:** Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Apollo Valve
 - b. Crane; Crane Energy Flow Solutions

- c. Hammond Valve
 - d. KITZ Corporation
 - e. Milwaukee Valve Company
 - f. NIBCO Inc.
 - g. Or approved equal
 - 2. Description:
 - a. Standard: MSS SP-80, Type 4.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Horizontal flow.
 - d. Body Material: ASTM B 62, bronze.
 - e. Ends: Threaded.
 - f. Disc: PTFE.
- C. Class 125, Iron Swing Check Valves with Nonmetallic-to-Metal Seats:
- 1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Crane; Crane Energy Flow Solutions
 - b. NIBCO
 - c. Apollo Valves
 - d. Or approved equal
 - 2. Description:
 - a. Standard: MSS SP-71, Type I.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 150 psig.
 - d. Body Design: Clear or full waterway.
 - e. Body Material: ASTM A 126, gray iron with bolted bonnet.
 - f. Ends: Flanged.
 - g. Trim: Composition.
 - h. Seat Ring: Bronze.
 - i. Disc Holder: Bronze.
 - j. Disc: PTFE.
 - k. Gasket: Asbestos free.

2.6 AIR VENTS

- A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Bell and Gossett.
 2. Taco.
 3. Hoffman.
 4. Armstrong.
 5. Or approved equal.
- B. Manual Type: 3 inch tall vertical sections of 2 inch diameter pipe to form air chamber, with 1/4 inch ball valve at top of chamber with hose bibb and cap.
- C. Automatic Float Type:
1. Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve piped to approved plumbing receptor.

2.7 DRAIN VALVES

- A. General
1. Full-port ball valve, hose-end pattern with chained, gasketed caps.
 2. Standard lever handles as default.
 3. In constrained locations, tee handles may be used.
 4. Extended stem requirements apply for insulated piping.
 5. Minimum size shall be 3/4-inch. Larger as indicated. For main piping larger than 4 inches, drain valves shall be 1.5-inch, full-port and hose-end.
- B. Manufacturers:
1. NIBCO, Inc.
 2. Crane Valve, North America.
 3. Red Valve Company.
 4. Or approved equal
- C. 3/4 inch minimum, MSS SP 110, 600 psi WOG, two-piece bronze body, chrome plated brass ball, full port, Teflon seats, blow-out proof stem, solder or threaded ends, lever handle, hose cap and chain. Provide stem extension for insulated applications.

2.8 PRESSURE AND SAFETY RELIEF VALVES

- A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

- B. Watts.
 - 1. Consolidated.
 - 2. Kunkle.
 - 3. Manufacturer of equipment requiring the safety relief valve.
 - 4. Or approved equal.
- C. Valve: Bronze body, Teflon seat, stainless steel valve spring, and trim, automatic direct pressure actuated, capacities ASME certified and labeled.
- D. Type and size as applicable, constructed and rated in accordance with ASME BPVC Section VIII, Division 1, and so stamped.
- E. Piped to safe location outdoors for steam, and to a safe point of disposal for water where outdoor relief is not practical .
- F. Use "pressure relief valves" for unheated liquids.
- G. Use "safety relief valves" for heated liquids.
- H. Valves suitable and rated for proper temperatures; for "safety relief valves" minimum temperature rating is saturated steam temperature corresponding to pressure 10 percent higher than valve set pressure.
- I. Valves shall have set pressure indicated but not more than working pressure of protected equipment.
- J. Valves shall open, under test, at set pressure, with tolerance of plus or minus 2 psi for set pressures up to 70 psig, and plus or minus 3 percent for set pressures in excess of 70 psig.
- K. Valves shall have capacity to relieve maximum possible generated energy while maintaining pressure in protected equipment at no more than 10 percent above vessel working pressure.
- L. Provide multiple valves if required for capacity even though only one valve may be shown on Drawings.

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.
- 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 press fittings to verify they have been properly pressed.
- F. Do not attempt to repair defective valves; replace with new valves. Remove defective valves from site.

3.2 INSTALLATION OF VALVES

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Provide support of piping adjacent to valves such that no force is imposed upon valves.
- C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.
- D. For valves in horizontal piping, install valves with stem at or above center of pipe.

- E. Install valves in position that does not project into aisles or block access to other equipment.
- F. Install valves in position to allow full stem and actuator or manual operator movement.
- G. Verify that joints of each valve have been properly installed and sealed to ensure that there is no leakage or damage.
- H. Chainwheels: Install chainwheels on manual operators for globe valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.
- I. Install check valves for proper direction of flow and as follows:
 - 1. Check Valves: Center-guided type, in horizontal or vertical position, between flanges.
 - 2. Check Valves, Swing Type: In horizontal position with hinge pin level.
 - 3. Check Valves, Lift Type: With stem upright and plumb.
- J. Valve Tags: Comply with requirements for valve tags and schedules in Section 23 05 53 "Identification for HVAC Piping and Equipment."
- K. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve of manufacturer's written recommended maximum.

3.3 TESTING

- A. Test valve bonnets for tightness. Operate valves from closed-to-open-to-closed position while valve is under test pressure.
- B. Test automatic valves including solenoid valves, expansion valves, water regulating valves, pressure reducing valves, pressure relief valves, safety valves and temperature and pressure relief valves for proper operation at settings indicated.
- C. Insure that valves are field checked for packing and lubricant and that disc is for service intended. Replace leaking packing. Service valves which do not operate smoothly and properly with suitable lubricant before placing in operation.

- D. Test relief valves, safety relief valves, safety valves and temperature and pressure relief valves three times. Demonstrate that the valves seat properly after testing, without weeping.

3.4 ADJUSTING

- A. Adjust or replace valve packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.5 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- B. 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. For Copper Tubing, NPS 5 and Larger: Flanged ends.
 - 4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
 - 5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 - 6. For Steel Piping, NPS 5 and Larger: Flanged ends.
- C. If valve applications are not indicated, use the following:
 - 1. Shutoff Service: Ball, butterfly valves.
 - 2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
 - 3. Throttling Service except Steam: Globe, ball, or butterfly valves.
 - 4. Throttling Service, Steam: Globe valves.
 - 5. Pump-Discharge Check Valves:
 - a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
 - b. NPS 2-1/2 and Larger: Silent-Lift type check valves.
- D. Select valves, except wafer types, 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 Steel Piping, NPS 2 and Smaller: Threaded ends.
3. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
4. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.6 HEATING-WATER VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller: One or Two piece, full port, brass or bronze with bronze trim.
 1. Valves may be provided with solder-joint ends instead of threaded ends for sizes up to 1-inch.
- B. Pipe NPS 2-1/2 and Larger:
 1. Iron ball valves.
 - a. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
 2. Class 150 steel-body ball valves, SS ball and trim.
- C. Pipe NPS 2-1/2 and Larger: Iron Gate Valves, Class 125, NRS.
- D. Pipe NPS 2 and Smaller: Bronze angle or globe valves, Class 125, PTFE disc, with soldered or threaded ends.
- E. Pipe NPS 2-1/2 and Larger: Iron globe valves, Class 125, Class 250 with flanged ends.
- F. Pipe NPS 2-1/2 and Larger:
 1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: 200 CWP, EPDM seat, aluminum-bronze disc.
 2. High-Performance Butterfly Valves: Class 150, Class 300, single flange.
- G. Pipe NPS 2 and Smaller Check:
 1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
 2. Bronze Swing Check Valves: Class 125, PTFE disc.
- H. Pipe NPS 2-1/2 and Larger Check:

1. Iron Swing Check Valves: Class 125, non-metal seats.
2. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring.

3.7 AIR VENT AND DRAIN VALVE APPLICATION

Equipment type	Required locations	Comments
Manual air vents	Tops of risers	Pipe to the nearest approved receptor drain with ¼" copper tubing OR Provide threaded discharge connection with hose run to nearest receptor for use during construction. After hydrostatic tests and air purge, remove air vents and return to Owner's Representative for storage.
Manual air vents	On each side of each heat-transfer device Each high point in the piping system on the floor layout	Provided threaded hose end connection
Manual drain valves	Bottoms of risers	Minimum 3/4-inch, with threaded hose end connection for. Coordinate with plumbing for nearby approved receptor drain.
Manual drain valves	On each side of each heat-transfer device Each piping system low point At each mains shut-off valve.	¾-inch size default minimum. Provide 1-1/2-inch size drains for all piping greater than 4-inches. Provided threaded hose end connection

END OF SECTION

SECTION 23 05 29

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe hangers and supports - metal.
2. Pipe hangers - metal, trapeze type.
3. Strut support systems – metal, rod type.
4. Strut support systems – rooftop mounted.
5. Fastener systems.
6. Equipment supports.
7. Equipment stands - outdoor type.

B. Related Requirements:

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 "Vibration and Seismic Controls for HVAC" for vibration isolation devices.
4. Section 233113 "Metal Ducts" for duct hangers and supports.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
 - B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:
 1. Trapeze pipe hangers.
 2. Metal strut support systems.
 3. Rooftop-mounted strut support systems.
 4. FRP strut support systems.
 5. Pipe stands.
 6. Equipment supports.
 - C. Delegated Design Submittals: 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/assembly and design calculations for trapeze hangers.
 2. Detail fabrication/assembly and design calculations for each type of strut support system, by the manufacturer's technical representative.
- 1.3 INFORMATIONAL SUBMITTALS
- A. Welding certificates.
- 1.4 QUALITY ASSURANCE
- A. Structural-Steel Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - B. Pipe Welding Qualifications: Qualify procedures and operators in accordance with 2021 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 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.
 - 3. Design seismic-restraint hangers and supports for piping and equipment.

2.2 PIPE HANGERS AND SUPPORTS - METAL

- A. Pipe Hangers and Supports - Carbon Steel:
 - 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 washers made of [**carbon steel**] [**stainless steel**] <Insert material>.
- B. Pipe Hangers and Supports - Stainless Steel:
 - 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. Pipe/Tube Hangers and Supports - Copper:

1. Description: MSS SP-58, Types 1 through 58, copper-plated steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-plated steel.

2.3 PIPE HANGERS - METAL, TRAPEZE TYPE

- 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 STRUT SUPPORT SYSTEMS - METAL, ROD TYPE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. ABB (Electrification Products Division).
 2. Atkore International (Unistrut).
 3. Eaton (B-line).
 4. Flex-Strut Inc.
 5. G-Strut.
 6. Haydon Corporation.
 7. MIRO Industries.
 8. Wesanco, Inc.
 9. Description: Shop- or field-fabricated, pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
- B. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
- C. Channels: Continuous slotted carbon-steel channel with inturned lips.
- D. Channel Width: Selected for applicable load criteria.
- E. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
- F. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

- G. Metallic Coating: Hot-dip galvanized.

2.5 STRUT SUPPORT SYSTEMS - ROOFTOP MOUNTED

- A. General Requirements: Shop-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Pipe Stand - Compact:
 - 1. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
 - 2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
 - 3. Hardware: Galvanized steel or polycarbonate.
 - 4. Accessories: Protection pads.
- C. Pipe Stand - Single Base, Single Pipe, Low Profile:
 - 1. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 - 2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
 - 3. Vertical Members: Two, galvanized-steel, continuous-thread 1/2-inch (12-mm) rods.
 - 4. Horizontal Member: Adjustable horizontal, galvanized-steel pipe support channels.
 - 5. Pipe Supports: Roller.
 - 6. Hardware: Galvanized steel.
 - 7. Accessories: Protection pads.
 - 8. Height: 12 inches (300 mm) above roof.
- D. Pipe Stand - Single Base, Single Pipe, High Profile:
 - 1. Description: Single base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 - 2. Base: Single vulcanized rubber or molded polypropylene.
 - 3. Vertical Members: Two, galvanized-steel, continuous-thread 1/2-inch (12-mm) rods.
 - 4. Horizontal Member: One, adjustable height, galvanized--steel pipe support slotted channel or plate.
 - 5. Pipe Supports: Roller.
 - 6. Hardware: Galvanized steel.
 - 7. Accessories: Protection pads, 1/2-inch (12-mm) continuous-thread galvanized-steel rod.
 - 8. Height: 36 inches (900 mm) above roof.
- E. Pipe Stand - Multiple Pipe, High Profile:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
 2. Bases: Two or more; vulcanized rubber.
 3. Vertical Members: Two or more, galvanized-steel channels.
 4. Horizontal Members: One or more, adjustable height, galvanized-steel pipe support.
 5. Pipe Supports: Roller.
 6. Hardware: Galvanized steel.
 7. Accessories: Protection pads, 1/2-inch (12-mm) continuous-thread rod.
 8. Height: 36 inches (900 mm) above roof.
- F. Pipe Stand - Curb-Mounted Type: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.6 FASTENER SYSTEMS

- A. Fastener System - Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities required for supported loads and building materials where used.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hilti, Inc.
 - b. ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - c. MKT Fastening, LLC.
 - d. Simpson Strong-Tie Co., Inc.
- B. Fastener System - Mechanical-Expansion Anchors: Insert-wedge-type anchors for use in hardened portland cement concrete; with pull-out, tension, and shear capacities required for supported loads and building materials where used.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Eaton (B-line).
 - b. Empire Tool and Manufacturing Co., Inc.
 - c. Hilti, Inc.
 - d. ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - e. MKT Fastening, LLC.
 2. Indoor Applications: stainless-steel.
 3. Outdoor Applications: Stainless steel.

2.7 EQUIPMENT SUPPORTS

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

2.8 EQUIPMENT STANDS, OUTDOOR TYPE

- A. Description: Individual foot supports with elevated adjustable channel cross bars and clamps/fasteners/bolts for ground- or roof-supported outdoor equipment components, without roof membrane penetration, in a prefabricated system that can be modularly-assembled on site.
- B. Foot Material: Rubber or polypropylene.
- C. Rails Material: Hot dip galvanized carbon steel.
- D. Wind/Sliding Load Resistance: Up to 100 mph (44 mps) minimum.

2.9 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; galvanized.
 - D. Stainless Steel: ASTM A240/A240M.
 - E. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.
 - F. 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 static loads within specified loading limits. Minimum static design load used for strength determination is to include weight of supported components plus 200 lb (90 kg).

3.2 INSTALLATION OF HANGERS AND SUPPORTS

- A. 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.
- B. Install lateral bracing with pipe hangers and supports to prevent swaying.
- C. 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 (DN 65) and larger and at changes in direction of piping. Coordinate location of concrete inserts before concrete is placed.
- D. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- E. 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.
- F. 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. Thermal-hanger shield inserts may be used as an option. 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 are to span an arc of 180 degrees.
 - a. Thermal-hanger shield inserts may be used as an option. 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.
- G. 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.
- H. 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 in accordance with ASTM A36/A36M, carbon-steel shapes selected for loads being supported. Weld steel in accordance with AWS D1.1/D1.1M.
- I. Strut System Installation: Metal. Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems.
- J. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- K. Fastener System Installation:
1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick after concrete is placed and cured. Use installers that are licensed by powder-actuated tool manufacturer.
 2. Install mechanical-expansion anchors after concrete is placed and completely cured.
 3. Install fasteners in accordance with manufacturer's written instructions.
 4. Install lag screw wood fasteners in accordance with manufacturer's written instructions.
- L. 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.
- M. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- N. Equipment Support Installation:
1. Fabricate from welded-structural-steel shapes.
 2. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
 3. Grouting: Place grout under supports for floor-mounted equipment, and make bearing surface smooth.

4. Provide lateral bracing, to prevent swaying.

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.
- 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 (40 mm).

3.5 PAINTING

- A. Touchup:
 1. 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.

- a. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).
2. Comply with requirements in Section 099113 "Exterior Painting" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
3. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780/A780M.

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 stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.
- G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
- H. Use padded hangers for piping that is subject to scratching.
- I. Use thermal-hanger shield inserts for insulated piping and tubing.
- J. 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 (DN 15 to DN 750).
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), 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 (DN 20 to DN 200).
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
9. 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).
10. 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).
11. 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).
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
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 (DN 100 to DN 900), 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 (DN 100 to DN 900), 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 (DN 65 to DN 900) 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 (DN 25 to DN 750), 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 (DN 65 to DN 600), 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 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is unnecessary.
 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is unnecessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- K. 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 (DN 24 to DN 600).
 2. 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.
- L. 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 (150 mm) for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) 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 (49 to 232 deg C) piping installations.
- M. 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 (340 kg).
 - b. Medium (MSS Type 32): 1500 lb (680 kg).
 - c. Heavy (MSS Type 33): 3000 lb (1360 kg).
 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.
- N. 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.
- O. 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 (32 mm).
 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.
- P. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION

SECTION 23 05 48

VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

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. Housed-spring isolators.
 - 3. Spring hangers.
 - 4. 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 220548.13 "Vibration Controls for Plumbing Piping and Equipment" for devices for plumbing 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. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.
3. Annotate to indicate application of each product submitted and compliance with requirements.
4. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Shop Drawings:

1. Detail fabrication and assembly of equipment bases.
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: For each vibration isolation and seismic-restraint device.

1. Include design calculations and details for selecting vibration isolators, seismic restraints, and vibration isolation bases complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and seismic forces required to select vibration isolators and seismic restraints and for designing vibration isolation bases.
 - a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
4. Seismic-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

- c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
- d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for HVAC 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. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-mounting systems 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."
- C. Wind-Load-Restraint Device Load Ratings: Devices to be tested and rated in accordance with applicable code requirements and authorities having jurisdiction. Devices to be listed by a nationally recognized third party that requires periodic follow-up inspections and has a listing directory available to the public. Provide third-party listing by one or more of the following: an agency acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: 133 mph.
2. Building Classification Category: IV.
3. Minimum 10 lb/sq. ft. multiplied by maximum area of HVAC component projected on vertical plane normal to wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: D.
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: III.
 - a. Component Importance Factor: 1.5.
 - b. Component Response Modification Factor: 2.5.
 - c. Component Amplification Factor for Mechanical and Electrical Components: 2.5.
 - d. Component Amplification Factor for Distribution Systems: 9.
3. Design Spectral Response Acceleration at Short Periods (0.2 Second): 29%.
4. Design Spectral Response Acceleration at 1.0-Second Period: 11%.
5. Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

2.2 ELASTOMERIC ISOLATION PADS

A. Elastomeric Isolation Pads:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ace Mountings Co., Inc.
 - b. CADDY; nVent.
 - c. California Dynamics Corporation.
 - d. Isolation Technology, Inc.
 - e. Kinetics Noise Control, Inc.
 - f. Korfund.
 - g. Mason Industries, Inc.
 - h. Novia; A Division of C&P.
 - i. Vibration Eliminator Co., Inc.
 - j. Vibration Isolation.
 - k. Vibration Management Corp.
2. Vibration Mountings & Controls, Inc.

3. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
4. Size: Factory or field cut to match requirements of supported equipment.
5. Minimum deflection as indicated on Drawings.
6. Pad Material: Oil- and water-resistant rubber.
7. Infused nonwoven cotton or synthetic fibers.
8. Load-bearing metal plates adhered to pads.
9. Sandwich-Core Material: Resilient and elastomeric.
 - a. Infused nonwoven cotton or synthetic fibers.

2.3 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. Ace Mountings Co., Inc.
 - b. CADDY; nVent.
 - c. California Dynamics Corporation.
 - d. Isolation Technology, Inc.
 - e. Kinetics Noise Control, Inc.
 - f. Korfund.
 - g. Mason Industries, Inc.
 - h. Vibration Eliminator Co., Inc.
 - i. Vibration Isolation.
 - j. Vibration Management Corp.
 2. Vibration Mountings & Controls, Inc.
 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.
 8. 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 (3447 kPa).
 - b. Top housing with threaded mounting holes and internal leveling device.

2.4 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. CADDY; brand of nVent Electrical plc.
 - b. Mason Industries, Inc.
 - c. NOVIA; a division of Carpenter & Paterson.
 - 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 (3447 kPa).
 - b. Top plate with 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.

2.5 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. Ace Mountings Co., Inc.
 - b. CADDY; nVent.
 - c. California Dynamics Corporation.
 - d. Kinetics Noise Control, Inc.
 - e. Mason Industries, Inc.
 - f. Novia; A Division of C&P.
 - g. Vibration Eliminator Co., Inc.
 - h. Vibration Isolation.
 - i. Vibration Management Corp.
 2. Vibration Mountings & Controls, Inc.

3. 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.
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. Minimum deflection as indicated on Drawings.
8. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
9. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
10. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
11. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.6 VIBRATION ISOLATION EQUIPMENT BASES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. CADDY; nVent.
 2. California Dynamics Corporation.
 3. Kinetics Noise Control, Inc.
 4. Mason Industries, Inc.
 5. Novia; A Division of C&P.
 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 (25-mm) 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 (25-mm) 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 (25-mm) 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 and seismic-control 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 by an agency acceptable to authorities having jurisdiction.

- B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners 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 and wind force loads within specified loading limits.

3.3 INSTALLATION OF VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICES

- A. Provide vibration and seismic-control devices for systems and equipment where indicated in Equipment Schedules or Vibration-Control Device Schedules on Drawings, where Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.
- B. 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."
- C. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.
- D. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- E. Equipment Restraints:
 - 1. Install snubbers on HVAC 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 (3.2 mm).
 - 3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- F. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.
 - 2. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
 - 3. Brace a change of direction longer than 12 feet (3.7 m).

- G. Install cables so they do not bend across edges of adjacent equipment or building structure.
- H. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- 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 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. Wedge-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 VIBRATION ISOLATION EQUIPMENT BASES INSTALLATION

- A. Coordinate the 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."

3.5 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 232113 "Hydronic Piping" for piping flexible connections.

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. Perform tests and inspections.
- D. Tests and Inspections:
 - 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 - 2. 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.
 - 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 - 4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 - 5. Test to 90 percent of rated proof load of device.
 - 6. Measure isolator restraint clearance.
 - 7. Measure isolator deflection.
 - 8. Verify snubber minimum clearances.
 - 9. Test and adjust restrained-air-spring isolator controls and safeties.

- E. Remove and replace malfunctioning units and retest as specified above.
- F. Prepare test and inspection reports.

END OF SECTION

SECTION 23 05 53

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Warning tape.
4. Pipe labels.
5. Duct labels.
6. Stencils.
7. Valve tags.
8. Warning tags.

1.2 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:** Provide for each piping system. Include in operation and 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. Seton Name Plate Corporation
 - b. Marking Services Incorporated
 - c. Metalcraft
 - d. Approved Equal
2. Material and Thickness: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
3. Letter Color: Black
4. Background Color: White
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 rivets
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick and having predrilled holes for attachment hardware.
2. Letter Color: Black
3. Background Color: White
4. Maximum Temperature: Able to withstand temperatures of up to 160 deg F (71 deg C).
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless steel rivets or self-tapping screws.
8. 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.

2.2 WARNING SIGNS AND LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Seton Name Plate Corporation
 - 2. Marking Services Incorporated
 - 3. Metalcraft
 - 4. Approved Equal
- 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 of up to 160 deg F (71 deg C).
- F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
- G. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- H. Fasteners: Stainless steel rivets or self-taping screws.
- I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- J. Arc-Flash Warning Signs: Provide arc-flash warning signs in locations and with content in accordance with requirements of OSHA and NFPA70E and other applicable codes and standards.

- K. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 WARNING TAPE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Seton Name Plate Corporation
 - 2. Marking Services Incorporated
 - 3. Metalcraft
 - 4. Approved Equal
- B. Material: Vinyl.
- C. Minimum Thickness: 0.005 inch (0.12 mm).
- D. Letter Color: Black
- E. Background Color: Yellow
- F. Waterproof Adhesive Backing: Suitable for indoor or outdoor use.
- G. Maximum Temperature: 160 deg F (70 deg C).
- H. Minimum Width: 4 inches (100 mm).

2.4 PIPE LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Seton Name Plate Corporation
 - 2. Marking Services Incorporated
 - 3. Metalcraft
 - 4. Approved Equal
- B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.

- C. Letter and Background Color: As indicated for specific application under Part 3.
- D. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- E. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- F. 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: Size letters according to ASME A13.1 for piping, but no less than 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances.

2.5 DUCT LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Seton Name Plate Corporation
 - 2. Marking Services Incorporated
 - 3. Metalcraft
 - 4. Approved Equal
- B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
- C. General Requirements for Manufactured Duct Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction according to ASME A13.1.
- D. Letter and Background Color: As indicated for specific application under Part 3.
- E. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

- F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
- G. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances of up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- H. Fasteners: Stainless steel rivets or 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 the following:
- K. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings. Also include the following:
 - 1. Duct size.
 - 2. Flow-Direction Arrows: Include flow-direction arrows on main distribution ducts. Arrows may be either integral with label or may be applied separately.

2.6 STENCILS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Seton Name Plate Corporation
 - 2. Marking Services Incorporated
 - 3. Metalcraft
 - 4. Approved Equal
- B. Stencils for Piping:
 - 1. Lettering Size: Size letters according to ASME A13.1 for piping, but no less than 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.
 - 2. Stencil Material: Aluminum, Brass, Fiberboard, or metal to suit stencil durability required and to provide consistent edge definition and quality.
 - 3. Stencil Paint: Exterior, gloss, acrylic enamel colors complying with recommendations in ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.

4. Identification Paint: Exterior, alkyd enamelin colors according to ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.
5. Letter and Background Color: As indicated for specific application under Part 3.

C. Stencils for Ducts:

1. Lettering Size: Minimum letter height of 1-1/4 inches for viewing distances up to 15 feet and proportionately larger lettering for greater viewing distances.
2. Stencil Material: Aluminum, Brass, Fiberboard, or metal to suit stencil durability required and to provide consistent edge definition and quality.
3. Stencil Paint: Exterior, gloss, acrylic enamel in colors complying with recommendations in ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.
4. Identification Paint: Exterior, alkyd enamel in colors according to ASME A13.1 unless otherwise indicated, Paint may be in pressurized spray-can form
5. Letter and Background Color: As indicated for specific application under Part 3.

D. Stencils for Access Panels and Door Labels, Equipment Labels, and Similar Operational Instructions:

1. Lettering Size: Minimum letter height of 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.
2. Stencil Material: Aluminum, Brass, Fiberboard, or metal to suit stencil durability required and to provide consistent edge definition and quality.
3. Stencil Paint: Exterior, gloss, acrylic enamel in colors complying with recommendations in ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.
4. Identification Paint: Exterior, alkyd enamel in colors according to ASME A13.1 unless otherwise indicated, Paint may be in pressurized spray-can form.

2.7 VALVE TAGS

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

1. Seton Name Plate Corporation
2. Marking Services Incorporated
3. Metalcraft
4. Approved Equal

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 S-hook.
- C. Letter and Background Color: As indicated for specific application under Part 3.
- D. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) 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. Include valve-tag schedule in operation and maintenance data.

2.8 WARNING TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Seton Name Plate Corporation
 2. Marking Services Incorporated
 3. Metalcraft
 4. Approved Equal
- 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 (75 by 133 mm) minimum for any application. Approximately 4 by 7 inches for any application viewed from higher than standing height, or larger to suit full text at lettering size, not less than 1/2 inch height.
 2. Fasteners: /Brass grommet and wire. Reinforced grommet and wire or string for sizes larger than 4 inches minor dimension..
 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 incompatible primers, paints, and encapsulants, as well as dirt, oil, grease, release agents, and other substances that could impair bond of identification devices.

3.2 INSTALLATION, GENERAL 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.
- D. Locate identifying devices so that they are readily visible from the point of normal approach.

3.3 INSTALLATION OF EQUIPMENT LABELS, WARNING SIGNS, AND LABELS

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.
- C. Arc-Flash Warning Signs: Provide arc-flash warning signs on electrical disconnects and other equipment where arc-flash hazard exists, as indicated on Drawings, and in accordance with requirements of OSHA and NFPA 70E, and other applicable codes and standards.

3.4 INSTALLATION OF WARNING TAPE

- A. Warning Tape Color and Pattern: [Yellow background with black diagonal stripes] <Insert color, marking pattern, text>.

- B. Install warning tape on pipes and ducts, with cross-designated walkways providing less than 6 ft. (2 m) of clearance.
- C. Locate tape so as to be readily visible from the point of normal approach.

3.5 INSTALLATION OF PIPE LABELS

- A. Piping Color Coding: Painting of piping is specified in Section 099123 "Interior Painting."
- B. Install pipe labels showing service and flow direction with permanent adhesive on pipes.
- C. Pipe Label Locations: Locate pipe labels where piping is above accessible ceilings or exposed in finished spaces; in machine rooms; in accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Within 3 ft. (1 m) of 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. Within 3 ft. (1 m) of equipment items and other points of origination and termination.
 - 6. Spaced at maximum intervals of 25 ft. (8 m) along each run. Reduce intervals to 10 ft. (3.0 m) in areas of congested piping, ductwork, and equipment.
 - 7. On piping above inaccessible ceilings, omit intermediately spaced labels but provide labels at/near all points of ceiling access.
 - 8. Exceptions: where exposed in a finished space, label locations must be coordinated with Architect.
- D. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of 125 deg F (52 deg C) or higher. Where these pipes are to remain uninsulated, use a short section of insulation or use stenciled labels.
- E. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- F. Pipe Label Color Schedule:

1. Chilled-Water Piping: White letters on a safety-green background>.
2. Condenser-Water Piping: White letters on a safety-green background
3. Heating Water Piping: White letters on a safety-green background
4. Refrigerant Piping: Black letters on a safety-yellow background
5. Low-Pressure Steam Piping: White letters on a safety-green background
6. Steam Condensate Piping: White letters on a safety-green background

3.6 INSTALLATION OF DUCT LABELS

- A. Install plastic-laminated self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
 1. White letters on safety-green background: For cold-air supply ducts.
 2. White letters on safety-green background: For hot-air supply ducts.
 3. White letters on safety-blue background: For outside-, relief-, return-, and mixed-air ducts.
 4. Black letters on safety-yellow background: For exhaust air ducts
- B. Locate label near each point where ducts enter into and exit from concealed spaces and at maximum intervals of 20 ft. (6 m) where exposed or are concealed by removable ceiling system.
 1. Exceptions: where exposed in a finished space, label locations must be coordinated with Architect.
- C. Stenciled Access Panels and Door Labels, Equipment Labels, and Similar Operational Instructions:
 1. Black letters on White background.

3.7 INSTALLATION OF VALVE TAGS

- A. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule in the operating and maintenance manual.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in "Valve-Tag Size and Shape" Subparagraph below.

- C. 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. Chilled Water: 1-1/2 inches (38 mm), round
 - b. Glycol Water: 1-1/2 inches, round.
 - c. Refrigerant: 1-1/2 inches, round.
 - d. Hot Water: 1-1/2 inches, round.
 - e. Low-Pressure Steam: 1-1/2 inches, round.
 - f. Steam Condensate: 1-1/2 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
 - g. For each piping system, use the same lettering and background coloring system on valve tags as used for the Pipe Label Schedule text and background.

3.8 INSTALLATION OF WARNING TAGS

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

END OF SECTION

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

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. Testing, Adjusting, and Balancing of Air Systems:
 - a. Constant-volume air systems.
 - b. Variable-air-volume systems.
- 2. Testing, Adjusting, and Balancing of Hydronic Piping Systems:
 - a. Constant-flow hydronic systems.
 - b. Variable-flow hydronic systems.
 - c. Primary-secondary hydronic systems.
- 3. Testing, adjusting, and balancing of fuel oil systems for HVAC.
- 4. Testing, adjusting, and balancing of equipment.
 - a. VRF outdoor & Indoor heat pump
 - b. Dx split system
 - c. Air-Source heat pump
 - d. Energy Recovery unit
 - e. Electric heater
- 5. Sound tests.
- 6. Vibration tests.
- 7. Duct leakage tests verification.

TESTING, ADJUSTING, AND BALANCING FOR HVAC

8. Pipe leakage tests verification.
9. HVAC-control system verification.
10. Smoke-control system tests.

1.3 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. NEBB: National Environmental Balancing Bureau.
- C. TAB: Testing, adjusting, and balancing.
- D. TABB: Testing, Adjusting, and Balancing Bureau.
- E. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- F. TDH: Total dynamic head.
- G. UFAD: Underfloor air distribution.

1.4 PREINSTALLATION MEETINGS

- A. TAB Conference: Conduct a TAB conference at Worcester Firehouse 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. Air-Balance Report: Documentation indicating that Work complies with ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- B. TAB Report: Documentation indicating that Work complies with ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

- C. TAB Report: Documentation indicating that Work complies with ASHRAE/IES 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 **60** days of Contractor's Notice to Proceed, submit the Contract Documents review report, as specified in Part 3.
- C. Strategies and Procedures Plan: Within **60** 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 **90** 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:
 - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
 - 2. TAB Technician: Employee of the TAB specialist and certified by AABC.
- B. TAB Specialists Qualifications, Certified by **NEBB or TABB**:

1. TAB Field Supervisor: Employee of the TAB specialist and certified by **NEBB or TABB**
2. TAB Technician: Employee of the TAB specialist and certified by **NEBB or TABB**
- C. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."
- E. Code and AHJ Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

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 TAB SPECIALISTS

- A. Subject to compliance with requirements, engage one of the following:
 1. Air Solutions/Airadigm Solutions, Auburn, NH, Wilmington, MA
 2. Kevin S. Cox Associates, Inc. South Boston, MA
 3. Milharmer, Inc. Raynham, MA.
 4. Design Flow Associates, Halifax, MA
 5. Leonhardt, Inc., Wellesley, MA
 6. THB Company, Reading, MA
 7. Or Approved Equal.

3.2 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, gauge 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 and underfloor air plenums used for HVAC to verify that they are properly separated from adjacent areas and sealed.
- 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 temporary and permanent strainers. Verify that temporary strainer screens used during system cleaning and flushing have been removed and permanent strainer baskets are installed and clean.
- L. Examine control valves for proper installation for their intended function of isolating, 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. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.
- Q. 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.

3.3 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.
- 2. Hydronics:
 - a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
 - b. Piping is complete with terminals installed.
 - c. Water treatment is complete.
 - d. Systems are flushed, filled, and air purged.
 - e. Strainers are pulled and cleaned.
 - f. Control valves are functioning in accordance with the sequence of operation.
 - g. Shutoff and balance valves have been verified to be 100 percent open.
 - h. Pumps are started and proper rotation is verified.
 - i. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
 - j. Variable-frequency controllers' startup is complete and safeties are verified.
 - k. Suitable access to balancing devices and equipment is provided.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system in accordance with 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 casings 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. Where holes for probes are required in piping or hydronic equipment, install pressure and temperature test plugs to seal systems.
 - 4. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish in accordance with 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.

3.5 TESTING, ADJUSTING, AND BALANCING OF HVAC EQUIPMENT

- A. Test, adjust, and balance HVAC equipment indicated on Drawings, including, but not limited to, the following:
 - 1. Motors.
 - 2. Pumps.
 - 3. Fans and ventilators.
 - 4. Air curtains.
 - 5. Terminal units.
 - 6. Commercial kitchen hoods.
 - 7. Radiant heaters.
 - 8. Unit heaters.
 - 9. Heat exchangers.
 - 10. Condensing units.
 - 11. Condensers.
 - 12. Energy-recovery units.
 - 13. Air-handling units.
 - 14. Rooftop air-conditioning units.
 - 15. Dedicated outdoor-air units.
 - 16. Split-system air conditioners.
 - 17. Variable-refrigerant-flow systems.
 - 18. Heat pumps.
 - 19. Coils.
 - 20. Fan coil units.
 - 21. Unit ventilators.
 - 22. Radiant-heating **pipng and floor**

3.6 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' Record drawings 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.

3.7 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 main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
 - c. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - 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 Contractor-prepared shop drawings and Record drawings 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 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, speed, 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.

3.8 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. 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 main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
 - d. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
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.
 - 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, speed, 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.

3.9 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports for pumps, coils, and other equipment. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and equipment flow rates with pump design flow rate.
- B. Prepare schematic diagrams of systems' Record drawings piping layouts.
- C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
 1. Check expansion tank for proper setting.
 2. Check highest vent for adequate pressure.
 3. Check flow-control valves for proper position.

4. Locate start-stop and disconnect switches, electrical interlocks, and motor controllers.
 5. Verify that motor controllers are equipped with properly sized thermal protection.
 6. Check that air has been purged from the system.
- D. Measure and record upstream and downstream pressure of each piece of equipment.
- E. Measure and record upstream and downstream pressure of pressure-reducing valves.
- F. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.
1. Check settings and operation of each safety valve. Record settings.

3.10 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

- A. Adjust pumps to deliver total design flow.
1. Measure total water flow.
 - a. Position valves for full flow through coils.
 - b. Measure flow by main flow meter, if installed.
 - c. If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
 2. Measure pump TDH as follows:
 - a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - c. Convert pressure to head and correct for differences in gauge heights.
 - d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
 - e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.
 3. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.
- B. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
 2. Adjust main and branch balance valves for design flow.
 3. Re-measure each main and branch after all have been adjusted.
- C. Adjust flow-measuring devices installed at terminals for each space to design water flows.
1. Measure flow at terminals.
 2. Adjust each terminal to design flow.
 3. Re-measure each terminal after it is adjusted.
 4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
 5. Perform temperature tests after flows have been balanced.
- D. For systems with pressure-independent valves at terminals:
1. Measure differential pressure and verify that it is within manufacturer's specified range.
 2. Perform temperature tests after flows have been verified.
- E. For systems without pressure-independent valves or flow-measuring devices at terminals:
1. Measure and balance coils by either coil pressure drop or temperature method.
 2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
- F. Verify final system conditions as follows:
1. Re-measure and confirm that total water flow is within design.
 2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
 3. Mark final settings.
- G. Verify that memory stops have been set.

3.11 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

- A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.
- B. Adjust the variable-flow hydronic system as follows:

1. Verify that the pressure-differential sensor(s) is located as indicated.
 2. Determine whether there is diversity in the system.
- C. For systems with no flow diversity:
1. Adjust pumps to deliver total design flow.
 - a. Measure total water flow.
 - 1) Position valves for full flow through coils.
 - 2) Measure flow by main flow meter, if installed.
 - 3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
 - b. Measure pump TDH as follows:
 - 1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - 3) Convert pressure to head and correct for differences in gauge heights.
 - 4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
 - 5) With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.
 - c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.
 2. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - a. Measure flow in main and branch pipes.
 - b. Adjust main and branch balance valves for design flow.
 - c. Re-measure each main and branch after all have been adjusted.
 3. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 - a. Measure flow at terminals.
 - b. Adjust each terminal to design flow.
 - c. Re-measure each terminal after it is adjusted.
 - d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
 - e. Perform temperature tests after flows have been balanced.
 4. For systems with pressure-independent valves at terminals:
 - a. Measure differential pressure and verify that it is within manufacturer's specified range.
 - b. Perform temperature tests after flows have been verified.

5. For systems without pressure-independent valves or flow-measuring devices at terminals:
 - a. Measure and balance coils by either coil pressure drop or temperature method.
 - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
 6. Prior to verifying final system conditions, determine the system pressure-differential set point(s).
 7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
 8. Mark final settings and verify that all memory stops have been set.
 9. Verify final system conditions as follows:
 - a. Re-measure and confirm that total flow is within design.
 - b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
 - c. Mark final settings.
- D. For systems with flow diversity:
1. Determine diversity factor.
 2. Simulate system diversity by closing required number of control valves, as approved by Architect.
 3. Adjust pumps to deliver total design flow.
 - a. Measure total water flow.
 - 1) Position valves for full flow through coils.
 - 2) Measure flow by main flow meter, if installed.
 - 3) If main flow meter is not installed, determine flow by pump TDH or known equipment pressure drop.
 - b. Measure pump TDH as follows:
 - 1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - 3) Convert pressure to head and correct for differences in gauge heights.
 - 4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
 - 5) With valves open, read pump TDH. Adjust pump discharge valve or speed until design water flow is achieved. If excessive throttling is required to achieve desired flow, recommend pump impellers be trimmed to reduce excess throttling.

- c. Monitor motor performance during procedures, and do not operate motor in an overloaded condition.
4. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - a. Measure flow in main and branch pipes.
 - b. Adjust main and branch balance valves for design flow.
 - c. Re-measure each main and branch after all have been adjusted.
5. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 - a. Measure flow at terminals.
 - b. Adjust each terminal to design flow.
 - c. Re-measure each terminal after it is adjusted.
 - d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
 - e. Perform temperature tests after flows have been balanced.
6. For systems with pressure-independent valves at terminals:
 - a. Measure differential pressure, and verify that it is within manufacturer's specified range.
 - b. Perform temperature tests after flows have been verified.
7. For systems without pressure-independent valves or flow-measuring devices at terminals:
 - a. Measure and balance coils by either coil pressure drop or temperature method.
 - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system pressure-differential set point(s).
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion, open discharge valve 100 percent, and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:
 - a. Re-measure and confirm that total water flow is within design.
 - b. Re-measure final pumps' operating data, TDH, volts, amps, speed, and static profile.
 - c. Mark final settings.

3.12 PROCEDURES FOR MOTORS

- A. Motors $\frac{1}{2}$ 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.

3.13 PROCEDURES FOR AIR-COOLED CONDENSING UNITS

- A. Verify proper rotation of fan(s).
- B. Measure and record entering- and leaving-air temperatures.
- C. Measure and record entering and leaving refrigerant pressures.
- D. Measure and record operating data of compressor(s), fan(s), and motors.

3.14 PROCEDURES FOR AIR-COOLED CONDENSERS

- A. Verify proper rotation of fan(s).
- B. Measure and record entering- and leaving-air temperatures.
- C. Measure and record entering and leaving refrigerant pressures.
- D. Measure and record operating data of fan(s) and motor(s).

3.15 PROCEDURES FOR EXHAUST HOODS

- A. Room Pressure: Measure and record room pressure with respect to atmosphere and adjacent space with hoods in room initially not operating and then with hoods operating.
- B. Makeup Air: Systems supplying source of makeup air to hoods shall be in operation during testing and balancing of exhaust hoods.
 - 1. Measure and record temperature of makeup air entering hood. If hood makeup air is from multiple sources having different temperatures, measure and record the airflow and temperatures of each source and calculate the weighted average temperature.
 - 2. Use simulated smoke to observe supply air-distribution air patterns in vicinity of hoods. Consult with hood manufacturer and report conditions that have a detrimental effect on intended capture, containment, and other attributes effecting proper operation.
- C. Rooms with Multiple Hoods: Test each hood separately, one at a time, and repeat tests with all hoods intended to operate simultaneously by design.
- D. Kitchen Hoods:
 - 1. Type 1: Measure and record pressure drop and face velocity of hood filters and slots in accordance with hood manufacturer's instructions. Consult hood manufacturer to determine hood airflow using recorded information.
 - 2. Type 2: Measure and record airflow by duct traverse.
 - 3. Capture and Containment: Check each hood for proper capture and containment using a smoke-emitting device. Observe and report performance. Make adjustments to achieve optimum results.
- E. AHJ Tests: Conduct additional tests required by authorities having jurisdiction.

3.16 SOUND TESTS

- A. After systems are balanced and Substantial Completion, measure and record sound levels at **five** locations as designated by the Architect.
- B. Instrumentation:
 - 1. The sound-testing meter shall be a portable, general-purpose testing meter consisting of a microphone, processing unit, and readout.

2. The sound-testing meter shall be capable of showing fluctuations at minimum and maximum levels, and measuring the equivalent continuous sound pressure level (L_{eq}).
3. The sound-testing meter must be capable of using one-third octave band filters to measure mid-frequencies from 31.5 Hz to 8000 Hz.
4. The accuracy of the sound-testing meter shall be plus or minus one decibel.

C. Test Procedures:

1. Perform test at quietest background noise period. Note cause of unpreventable sound that affects test outcome.
2. Equipment should be operating at design values.
3. Calibrate the sound-testing meter prior to taking measurements.
4. Use a microphone suitable for the type of noise levels measured that is compatible with meter. Provide a windshield for outside or in-duct measurements.
5. Record a set of background measurements in dBA and sound pressure levels in the eight unweighted octave bands **63 Hz to 8000 Hz (NC)** with the equipment off.
6. Take sound readings in dBA and sound pressure levels in the eight unweighted octave bands **63 Hz to 8000 Hz (NC)** with the equipment operating.
7. Take readings no closer than 36 inches from a wall or from the operating equipment and approximately 60 inches from the floor, with the meter held or mounted on a tripod.
8. For outdoor measurements, move sound-testing meter slowly and scan area that has the most exposure to noise source being tested. Use A-weighted scale for this type of reading.

D. Reporting:

1. Report shall record the following:
 - a. Location.
 - b. System tested.
 - c. dBA reading.
 - d. Sound pressure level in each octave band with equipment on and off.
2. Plot sound pressure levels on **Noise Criteria (NC)** worksheet with equipment on and off.

3.17 VIBRATION TESTS

- A. After systems are balanced and Substantially Completion, measure and record vibration levels on equipment having motor horsepower equal to or greater than **10.**
- B. Instrumentation:
 - 1. Use portable, battery-operated, and microprocessor-controlled vibration meter with or without a built-in printer.
 - 2. The meter shall automatically identify engineering units, filter bandwidth, amplitude, and frequency scale values.
 - 3. The meter shall be able to measure machine vibration displacement in mils of deflection, velocity in inches per second, and acceleration in inches per second squared.
 - 4. Verify calibration date is current for vibration meter before taking readings.
- C. Test Procedures:
 - 1. To ensure accurate readings, verify that accelerometer has a clean, flat surface and is mounted properly.
 - 2. With the unit running, set up vibration meter in a safe, secure location. Connect transducer to meter with proper cables. Hold magnetic tip of transducer on top of the bearing, and measure unit in mils of deflection. Record measurement, then move transducer to the side of the bearing and record in mils of deflection. Record an axial reading in mils of deflection by holding nonmagnetic, pointed transducer tip on end of shaft.
 - 3. Change vibration meter to velocity (inches per second) measurements. Repeat and record above measurements.
 - 4. Record CPM or rpm.
 - 5. Read each bearing on motor, fan, and pump as required. Track and record vibration levels from rotating component through casing to base.
- D. Reporting:
 - 1. Report shall record location and the system tested.
 - 2. Include horizontal-vertical-axial measurements for tests.
 - 3. Verify that vibration limits follow Specifications, or, if not specified, follow the General Machinery Vibration Severity Chart or Vibration Acceleration General Severity Chart from AABC's "National Standards for Total System Balance." Acceptable levels of vibration are normally "smooth" to "good."
 - 4. Include in General Machinery Vibration Severity Chart, with conditions plotted.

3.18 DUCT LEAKAGE TESTS

- A. Witness the duct leakage testing performed by Installer.
- B. Verify that proper test methods are used and that leakage rates are within specified limits.
- C. Report deficiencies observed.

3.19 PIPE LEAKAGE TESTS

- A. Witness the pipe pressure testing performed by Installer.
- B. Verify that proper test methods are used and that leakage rates are within specified limits.
- C. Report deficiencies observed.

3.20 HVAC CONTROLS VERIFICATION

- A. In conjunction with system balancing, perform the following:
 - 1. Verify HVAC 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.

3.21 PROCEDURES FOR SMOKE-CONTROL SYSTEM TESTING

- A. Before testing smoke-control systems, review design documents to understand operating requirements and design intent:
 - 1. Review boundaries of each smoke zone.
 - 2. Review location, size, and operating characteristics of equipment, such as smoke and fire smoke dampers.
 - 3. Review sequence of operation, operating status of equipment, and position of smoke and fire dampers for each smoke zone alarm condition.
 - 4. Review location and type of alarm detection used to initiate smoke control for each smoke zone.
 - 5. Review other smoke-control system attributes not listed but required for code compliance and acceptance by authorities having jurisdiction.
- B. Before testing smoke-control systems, verify that construction is complete and verify the integrity of each smoke-control zone boundary.
 - 1. Verify that windows, doors, walls, ceilings, and floors (six-sided boundary) are closed and that applicable safing, gasket, and firestops and sealants are installed.
 - 2. Report deficiencies and postpone testing until after the reported deficiencies are corrected.
- C. Measure and record barometric pressure, wind speed and direction, outdoor-air temperature, and relative humidity on each test day.
- D. Measure, adjust, and record airflow of each smoke-control system, with all fans that are a part of system operating as intended by the design.
 - 1. Measure, adjust, and record the airflow of each fan. For ducted systems, measure fan airflow by duct Pitot-tube traverse.
 - 2. Measure, adjust, and record the airflow of each exhaust inlet and supply outlet.
 - 3. Measure, adjust, and record airflow in main and branch ducts.
- E. Smoke Control by Pressurization: After air balancing is complete, perform the following pressurization testing for each smoke-control zone in the system designed for isolation by using pressurization boundaries:
 - 1. Verify the boundaries of each smoke-control zone.
 - 2. With the HVAC systems in their normal mode of operation and smoke control not operating, measure and record the pressure difference across each

- smoke-control zone. Make measurements after closing doors that separate the zones. Make one measurement across each door. Clearly indicate the high- and low-pressure side of each door.
3. With the system operating in the smoke-control mode and with each separate zone in the smoke-control system activated, perform the following:
 - a. Measure and record the pressure difference across each door that separates the smoke zone from adjacent zones.
 - 1) Make measurements with doors that separate the smoke zone from the other zones closed.
 - 2) Clearly indicate the high- and low-pressure side of the door.
 - 3) Doors that have a tendency to open slightly due to the pressure difference should have one pressure measurement made while held closed and another measurement made with the door open.
 - b. Continue to activate each separate smoke zone within each smoke-control system, and make pressure-difference measurements.
 - c. After testing a smoke zone's smoke-control system, deactivate the HVAC systems involved and return them to their normal operating mode before activating another zone's smoke-control system.
 - d. Verify that controls necessary to prevent excessive pressure differences are functional and operating within design set points and limits.
 - F. Smoke-Control Systems for Atriums and Other Large-Volume Spaces: After air balancing is complete, perform the following testing for each smoke-control system serving atriums and other large-volume spaces:
 1. Verify and document the boundaries served by each smoke-control system.
 2. Identify and document closed doors, open doors, and other boundary openings to be left open to adjacent areas and that are to be protected by airflow alone.
 3. With the HVAC systems in their normal mode of operation and smoke-control systems not operating, measure and record the following:
 - a. Pressure difference across each door that separates the smoke-zone from adjacent zones.
 - b. Velocity for each point in traverse across each boundary opening:
 - 1) Clearly indicate the direction of flow.
 - 2) Measure velocity across opening on 12-inch centers using a vane anemometer.
 - 3) Calculate and report airflow.
 4. With system operating in the smoke-control mode, measure and record the following:
 - a. Pressure difference across each door that separates the smoke-zone from adjacent zones.
 - b. Velocity for each point in traverse across each opening:
 - 1) Clearly indicate the direction of flow.
 - 2) Measure velocity across opening on 12-inch centers using a vane anemometer.

- 3) Calculate and report airflow.
5. Verify system operation and make adjustments to achieve design pressure differences and air velocities within design set points and upper operating limits.
- G. Operational Tests:
1. Check the proper activation of each zone of each smoke-control system in response to all means of activation, both automatic and manual.
 2. Check automatic activation in response to fire alarm signals received from the building's fire alarm system. Initiate a separate alarm for each means of activation to ensure that the proper operation of the correct zone of each smoke-control system occurs.
 3. Check and record proper operation of fans, dampers, and related equipment for each separate zone of each smoke-control system:
 - a. Zone in which a smoke-control system automatically activates.
 - b. Type of signal that activates smoke-control system, such as sprinkler flow or smoke detector.
 - c. Smoke zone(s) where maximum mechanical exhaust to the outside is implemented and no supply air is provided.
 - d. Positive-pressure smoke-control zone(s) where maximum air supply is implemented and no exhaust to the outside is provided.
 - e. Fan(s) "ON" as required to implement the smoke-control system. Multiple- or variable-speed fans should be further noted to verify that the intended control configuration is achieved.
 - f. Fan(s) "OFF" as required to implement the smoke-control system.
 - g. Damper(s) "OPEN" or at an adjustable position where maximum airflow must be achieved.
 - h. Damper(s) "CLOSED" where no airflow should take place.
 - i. Auxiliary functions to achieve the smoke-control system configuration, such as changes or override of normal operating pressure and temperature-control set points.
 - j. If standby power is provided for the smoke-control system, test to verify that the system functions while operating under both normal and standby power.
 - k. Check operation in accordance with design indicated.
- H. AHJ Tests: Conduct additional tests required by authorities having jurisdiction. **[Unless required by authorities having jurisdiction, perform testing without the use of smoke or products that simulate smoke.]**
- I. Report: Prepare and submit a complete report of observations, measurements, and deficiencies. Include names and contact information of individuals conducting tests and of individuals witnessing tests.

3.22 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

- A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
 - 1. Measure and record the operating speed, airflow, and static pressure of each fan and equipment with fan(s).
 - 2. Measure and record flows, temperatures, and pressures of each piece of equipment in each hydronic system. Compare the values to design or nameplate information, where information is available.
 - 3. Measure motor voltage and amperage. Compare the values to motor nameplate information.
 - 4. Check the refrigerant charge.
 - 5. Check the condition of filters.
 - 6. Check the condition of coils.
 - 7. Check the operation of the drain pan and condensate-drain trap.
 - 8. Check bearings and other lubricated parts for proper lubrication.
 - 9. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.
- B. TAB After Construction: Before performing testing and balancing of renovated existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished in accordance with renovation scope indicated by Contract Documents. Verify the following:
 - 1. New filters are installed.
 - 2. Coils are clean and fins combed.
 - 3. Drain pans are clean.
 - 4. Fans are clean.
 - 5. Bearings and other parts are properly lubricated.
 - 6. Deficiencies noted in the preconstruction report are corrected.
- C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
 - 1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
 - 2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
 - 3. If calculations increase or decrease the airflow rates and water flow rates by more than **5** percent, make equipment adjustments to achieve the calculated

rates. If increase or decrease is **5 percent** or less, equipment adjustments are not required.

4. Balance each air outlet.

3.23 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 10 percent or minus 5 percent**. If design value is less than 100 cfm, within 10 cfm
 2. Air Outlets and Inlets: **Plus 10 percent or minus 5 percent**. If design value is less than 100 cfm, within 10 cfm
 3. Heating-Water Flow Rate: **Plus 10 percent or minus 5 percent**. If design value is less than 10 gpm, within 10 percent.
 4. Chilled-Water Flow Rate: **Plus 10 percent or minus 5 percent**. If design value is less than 10 gpm, within 10 percent.
 5. Condenser-Water Flow Rate: **Plus 10 percent or minus 5 percent**.
- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.24 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 system-balancing devices. Recommend changes and additions to system-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.

3.25 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 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. Heating coil, dry-bulb conditions.
 - e. Face and bypass damper settings at coils.
 - f. Fan drive settings, including settings and percentage of maximum pitch diameter.
 - g. **Inlet vane** settings for variable-air-volume systems.
 - h. Settings for pressure controller(s).
 - i. Other system operating conditions that affect performance.
- 16. Test conditions for pump performance forms, including the following:
 - a. Variable-frequency controller settings for variable-flow hydronic systems.
 - b. Settings for pressure controller(s).
 - c. 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, 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 (mm), and bore.
 - i. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
 - 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 speed.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.

- e. Sheave make, size in inches (mm), and bore.
 - f. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
3. Test Data (Indicated and Actual Values):
- a. Total airflow rate in cfm (L/s).
 - b. Total system static pressure in inches wg (Pa).
 - c. Fan speed.
 - d. Inlet and discharge static pressure in inches wg (Pa).
 - e. For each filter bank, filter static-pressure differential in inches wg (Pa).
 - f. Preheat-coil static-pressure differential in inches wg (Pa).
 - g. Cooling-coil static-pressure differential in inches wg (Pa).
 - h. Heating-coil static-pressure differential in inches wg (Pa).
 - i. List for each internal component with pressure-drop, static-pressure differential in inches wg (Pa).
 - j. Outdoor airflow in cfm (L/s).
 - k. Return airflow in cfm (L/s).
 - l. Outdoor-air damper position.
 - m. Return-air 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 (mm) o.c.
 - f. Make and model number.
 - g. Face area in sq. ft. (sq. m).
 - h. Tube size in NPS (DN).
 - i. Tube and fin materials.
 - j. Circuiting arrangement.
2. Test Data (Indicated and Actual Values):
- a. Airflow rate in cfm (L/s).
 - b. Average face velocity in fpm (m/s).
 - c. Air pressure drop in inches wg (Pa).
 - d. Outdoor-air, wet- and dry-bulb temperatures in deg F (deg C).
 - e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
 - f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
 - g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
 - h. Water flow rate in gpm (L/s).
 - i. Water pressure differential in feet of head or psig (kPa).
 - j. Entering-water temperature in deg F (deg C).
 - k. Leaving-water temperature in deg F (deg C).
 - l. Refrigerant expansion valve and refrigerant types.
 - m. Refrigerant suction pressure in psig (kPa).
 - n. Refrigerant suction temperature in deg F (deg C).

- o. Inlet steam pressure in psig (kPa).
 - G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
 - 1. Unit Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Fuel type in input data.
 - g. Output capacity in Btu/h (kW).
 - h. Ignition type.
 - i. Burner-control types.
 - j. Motor horsepower and speed.
 - k. Motor volts, phase, and hertz.
 - l. Motor full-load amperage and service factor.
 - m. Sheave make, size in inches (mm), and bore.
 - n. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
 - 2. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm (L/s).
 - b. Entering-air temperature in deg F (deg C).
 - c. Leaving-air temperature in deg F (deg C).
 - d. Air temperature differential in deg F (deg C).
 - e. Entering-air static pressure in inches wg (Pa).
 - f. Leaving-air static pressure in inches wg (Pa).
 - g. Air static-pressure differential in inches wg (Pa).
 - h. Low-fire fuel input in Btu/h (kW).
 - i. High-fire fuel input in Btu/h (kW).
 - j. Manifold pressure in psig (kPa).
 - k. High-temperature-limit setting in deg F (deg C).
 - l. Operating set point in Btu/h (kW).
 - m. Motor voltage at each connection.
 - n. Motor amperage for each phase.
 - o. Heating value of fuel in Btu/h (kW).
 - H. 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 (kW).
 - e. Number of stages.

- f. Connected volts, phase, and hertz.
 - g. Rated amperage.
 - h. Airflow rate in cfm (L/s).
 - i. Face area in sq. ft. (sq. m).
 - j. Minimum face velocity in fpm (m/s).
 - 2. Test Data (Indicated and Actual Values):
 - a. Heat output in Btu/h (kW).
 - b. Airflow rate in cfm (L/s).
 - c. Air velocity in fpm (m/s).
 - d. Entering-air temperature in deg F (deg C).
 - e. Leaving-air temperature in deg F (deg C).
 - f. Voltage at each connection.
 - g. Amperage for each phase.
- I. 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 (mm), and bore.
 - h. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
 - 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and speed.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches (mm), and bore.
 - f. Center-to-center dimensions of sheave and amount of adjustments in inches (mm).
 - g. Number, make, and size of belts.
 - 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm (L/s).
 - b. Total system static pressure in inches wg (Pa).
 - c. Fan speed.
 - d. Discharge static pressure in inches wg (Pa).
 - e. Suction static pressure in inches wg (Pa).
- J. 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 fan and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F (deg C).
 - d. Duct static pressure in inches wg (Pa).
 - e. Duct size in inches (mm).
 - f. Duct area in sq. ft. (sq. m).
 - g. Indicated airflow rate in cfm (L/s).
 - h. Indicated velocity in fpm (m/s).
 - i. Actual airflow rate in cfm (L/s).
 - j. Actual average velocity in fpm (m/s).
 - k. Barometric pressure in psig (Pa).
- K. 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. (sq. m).
 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm (L/s).
 - b. Air velocity in fpm (m/s).
 - c. Preliminary airflow rate as needed in cfm (L/s).
 - d. Preliminary velocity as needed in fpm (m/s).
 - e. Final airflow rate in cfm (L/s).
 - f. Final velocity in fpm (m/s).
 - g. Space temperature in deg F (deg C).
- L. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
 1. Unit Data:
 - a. System and air-handling-unit identification.
 - b. Location and zone.
 - c. Room or riser served.
 - d. Coil make and size.
 - e. Flowmeter type.
 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm (L/s).
 - b. Entering-water temperature in deg F (deg C).

- c. Leaving-water temperature in deg F (deg C).
 - d. Water pressure drop in feet of head or psig (kPa).
 - e. Entering-air temperature in deg F (deg C).
 - f. Leaving-air temperature in deg F (deg C).
- M. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves, and include the following:
 - 1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Service.
 - d. Make and size.
 - e. Model number and serial number.
 - f. Water flow rate in gpm (L/s).
 - g. Water pressure differential in feet of head or psig (kPa).
 - h. Required net positive suction head in feet of head or psig (kPa).
 - i. Pump speed.
 - j. Impeller diameter in inches (mm).
 - k. Motor make and frame size.
 - l. Motor horsepower and rpm.
 - m. Voltage at each connection.
 - n. Amperage for each phase.
 - o. Full-load amperage and service factor.
 - p. Seal type.
 - 2. Test Data (Indicated and Actual Values):
 - a. Static head in feet of head or psig (kPa).
 - b. Pump shutoff pressure in feet of head or psig (kPa).
 - c. Actual impeller size in inches (mm).
 - d. Full-open flow rate in gpm (L/s).
 - e. Full-open pressure in feet of head or psig (kPa).
 - f. Final discharge pressure in feet of head or psig (kPa).
 - g. Final suction pressure in feet of head or psig (kPa).
 - h. Final total pressure in feet of head or psig (kPa).
 - i. Final water flow rate in gpm (L/s).
 - j. Voltage at each connection.
 - k. Amperage for each phase.
- N. Instrument Calibration Reports:
 - 1. Report Data:
 - a. Instrument type and make.
 - b. Serial number.
 - c. Application.
 - d. Dates of use.
 - e. Dates of calibration.

3.26 VERIFICATION OF TAB REPORT

- A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of **Owner** and **Commissioning Authority**.
- B. Engineer shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to the lesser of 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 TAB shall be considered incomplete and shall be rejected.
- E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, 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. All changes shall be tracked to show changes made to previous report.
 - 2. If the second final inspection also fails, Owner may pursue others Contract options to complete TAB work.
- F. Prepare test and inspection reports.

3.27 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

SECTION 23 07 13

DUCT INSULATION

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 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, exposed, Type I, commercial, kitchen hood exhaust.
7. Indoor, concealed oven and warewash exhaust.
8. Indoor, exposed oven and warewash exhaust.
9. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
10. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
11. Outdoor, concealed supply and return.
12. Outdoor, exposed supply and return.

B. Related Requirements:

1. Section 230716 "HVAC Equipment Insulation."
2. Section 230719 "HVAC Piping Insulation."
3. Section 233113 "Metal Ducts" for duct liners.

1.2 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. Sustainable Design Submittals:

1. Product Data: For adhesives, indicating VOC content.
2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.
3. Product Data: For coatings, indicating VOC content.
4. Laboratory Test Reports: For coatings, indicating compliance with requirements for low-emitting materials.
5. Product Data: For sealants, indicating VOC content.
6. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.

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 (300 mm) square.
2. Sheet Jacket Materials: 12 inches (300 mm) 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.

1.3 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.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program, certified by the Department of Labor, Bureau of Apprenticeship and Training.

- B. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.
1. Ductwork Mockups:
 - a. One 10-foot (3-m) section each of rectangular and round straight duct.
 - b. One each of a 90-degree mitered round and rectangular elbow, and one each of a 90-degree radius round and rectangular elbow.
 - c. One rectangular branch takeoff and one round branch takeoff from a rectangular duct. One round tee fitting.
 - d. One rectangular and round transition fitting.
 - e. Four support hangers for round and rectangular ductwork.
 - f. Each type of damper and specialty.
 2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
 3. Notify Architect seven days in advance of dates and times when mockups will be constructed.
 4. Obtain Architect's approval of mockups before starting insulation application.
 5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 7. Demolish and remove mockups when directed.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers are to be marked with the manufacturer's name, appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 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.

1.7 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.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. 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, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.
 - 1. All Insulation Installed Indoors; Outdoors-Installed Insulation in Contact with Airstream: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 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 are to be applied.
- B. Products do not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel 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 are qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.
- F. Flexible Elastomeric: Closed-cell or expanded-rubber materials; suitable for maximum use temperature between minus 70 deg F (minus 57 deg C) and 220 deg F (104 deg C). Comply with ASTM C534, Type II for sheet materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA.
 - b. Armacell LLC.
 - c. K-Flex USA.
- G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290,. 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 C612, Type IA or Type IB. For duct and plenum applications, provide insulation 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.
- I. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) 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. Polyolefin: Polyethylene thermal plastic insulation. Comply with ASTM C1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armacell LLC.
 - b. Sekisui Voltek, LLC.
 - c. Thermaduct.

2.3 FIRE-RATED INSULATION SYSTEMS

- A. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F (927 deg C). Comply with ASTM C656, Type II, Grade 6. Tested and certified to provide a-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. Knauf
 - c. USG Boral

- B. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a-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; SAINT-GOBAIN.
 - c. Unifrax Corporation.

2.4 ADHESIVES

- A. Materials are 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.
 - b. Armacell LLC.
 - c. Foster Brand; H. B. Fuller.
 - d. K-Flex USA.
2. Verify adhesives have a VOC content of 50 g/L or less.

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.

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.
 - d. Mon-Eco Industries, Inc.
2. Verify adhesive has a VOC content of 80 g/L or less when calculated in accordance with 40 CFR 59, Subpart D (EPA Method 24).

E. 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. Proto Corporation.
2. Verify adhesive has a VOC content of 80 g/L or less when calculated in accordance with 40 CFR 59, Subpart D (EPA Method 24). Subparagraph below applies to IgCC.

2.5 MASTICS AND COATINGS

A. Materials are compatible with insulation materials, jackets, and substrates.

1. VOC Content: 300 g/L or less.

B. Vapor-Retarder Mastic, Water Based, Interior Use: Suitable for indoor use on below ambient services.

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

- a. Aeroflex USA.
 - b. Childers Brand; H. B. Fuller Construction Products.
 - c. Foster Brand; H. B. Fuller.
 - d. Knauf Insulation.
 2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 4. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.
 5. Color: White.
- C. Vapor-Retarder Mastic, Solvent Based, Interior Use: 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.
 - d. Mon-Eco Industries, Inc.
 2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
 3. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
 4. Color: White.
- D. Vapor-Retarder Mastic, Solvent Based, Exterior Use: Suitable for outdoor use on below ambient services.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA.
 - b. Childers Brand; H. B. Fuller Construction Products.
 - c. Eagle Bridges - Marathon Industries.
 - d. Foster Brand; H. B. Fuller.
 2. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
 3. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
 4. Color: White.
- E. 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.
- d. Knauf Insulation.
- 2. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm (0.66 metric perm) at manufacturer's recommended dry film thickness.
- 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
- 4. Color: White.

2.6 LAGGING ADHESIVES

- A. Description: Comply with MIL-A-3316C, Class I, Grade A and are compatible with insulation materials, jackets, and substrates.
 - 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.
 - c. Vimasco Corporation.
 - 2. Verify adhesives have a VOC content of 50 g/L or less.
 - 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 (Minus 18 to plus 82 deg C).
 - 5. Color: White.

2.7 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.
 - d. Mon-Eco Industries, Inc.
 - 2. Materials are 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 (Minus 40 to plus 121 deg C).
 - 5. Color: Aluminum.
 - 6. Verify sealant has a VOC content of 420 g/L or less.
- B. ASJ Flashing Sealants, and Vinyl and PVC 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. Foster Brand; H. B. Fuller.
 - c. Mon-Eco Industries (MEI)
2. Materials are 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 (Minus 40 to plus 121 deg C).
5. Color: White.
6. Verify sealant has a VOC content of 420 g/L or less.

2.8 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 C1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
 4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.
 5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested in accordance with ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.
 6. ASJ+: All-service jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136, Types I, II, III, IV, and VII.
 7. PSK Jacket: Aluminum foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

2.9 FIELD-APPLIED JACKETS

- A. Field-applied jackets comply with ASTM C921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. P.I.C. Plastics, Inc.
 - c. Proto Corporation.
 - d. Speedline Corporation.
 2. Adhesive: As recommended by jacket material manufacturer.
 3. Color: White.
- D. Metal Jacket:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. RPR Products, Inc.
 - c. Childers
 2. Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Sheet and roll stock ready for shop or field sizing.
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.
 - d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
 3. Stainless Steel Jacket: ASTM A240/A240M.
 - a. Sheet and roll stock ready for shop or field sizing.
 - b. Material, finish, and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.
 - d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
- E. Self-Adhesive Outdoor Jacket (Asphaltic): 60-mil- (1.5-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross laminated polyethylene film covered with white aluminum-foil facing.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Foster Brand; H. B. Fuller.
 - b. MFM Building Products Corp.
 - c. Polyguard Products, Inc.

2.10 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass-Fiber Mesh: Approximately 6 oz./sq. yd. (203 g/sq. m) with a thread count of 5 strands by 5 strands/sq. in. (2 strands by 2 strands/sq. mm) for covering ducts.
 - 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.
 - c. Vimasco Corporation
- B. Woven Polyester Mesh: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for ducts.
 - 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.
 - c. Vimasco Corporation.

2.11 FIELD-APPLIED CLOTHS

- A. Woven Glass-Fiber Cloth: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Alpha Engineered Composites.
 - b. Auburn Manufacturing Inc.
 - c. GLT Products

2.12 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Aeroflex USA.
 - c. Avery Dennison Corporation, Specialty Tapes Division.
 - d. Ideal Tape Co., Inc., an American Biltrite Company.
 - e. Knauf Insulation.

2. Width: 3 inches (75 mm).
 3. Thickness: 11.5 mils (0.29 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) 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 C1136.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 2. Width: 3 inches (75 mm).
 3. Thickness: 6.5 mils (0.16 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) 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. 3M Industrial Adhesives and Tapes Division.
 - b. Ideal Tape Co., Inc., an American Biltrite Company.
 - c. Johns Manville.
 2. Width: 2 inches (50 mm).
 3. Thickness: 6 mils (0.15 mm).
 4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
 5. Elongation: 500 percent.
 6. Tensile Strength: 18 lbf/inch (3.3 N/mm) 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. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 - e. Sekisui Voltek, LLC.
 2. Width: 2 inches (50 mm).
 3. Thickness: 3.7 mils (0.093 mm).
 4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
 5. Elongation: 5 percent.

6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.13 SECUREMENTS

A. Bands:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. RPR Products, Inc.
 - c. AGM Industries.
2. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) wide with wing seal.
3. Aluminum: ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide with wing seal.
4. 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, [**0.106-inch- (2.6-mm-)**] [**0.135-inch- (3.5-mm-)**] 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) Midwest Fasteners, Inc.
 - 4) Nelson Stud Welding.
 - b. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- (3.5-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
 - c. 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) Midwest Fasteners, Inc.
 - 5) Nelson Stud Welding.
 - d. 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:
 - e. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - f. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - g. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - h. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
2. 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.
 - b. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
 - c. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

3. 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) Midwest Fasteners, Inc.
 - b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive-backed base with a peel-off protective cover.
4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - 4) 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.
5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Gemco.
 - 2) Midwest Fasteners, Inc.
 - b. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

C. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. C & F Wire Products.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. RPR Products, Inc.

2.14 CORNER ANGLES

- A. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC in accordance with ASTM D1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum in accordance with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14.
- C. Stainless Steel Corner Angles: 0.024 inch (0.61 mm) thick, minimum 1 by 1 inch (25 by 25 mm), stainless steel in accordance with ASTM A240/A240M, Type 304 or Type 316.

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, compress, or otherwise damage insulation or jacket.
- 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. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with Contract Documents, unless otherwise approved by the engineer-of-record.
- 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, but not to the extent of creating wrinkles or areas of compression in the insulation.

2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) 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.
- 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 (100 mm) 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 (50 mm) 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 (50 mm).
 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 (50 mm).
 - 1. Comply with requirements in Section 078413 "Penetration Firestopping."
- 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 (50 mm).
 - 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC AND POLYOLEFIN INSULATION

- A. Comply with manufacturer's written installation instructions and ASTM C1710.
- B. 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.
- C. Square and Rectangular Ducts and Plenums:
 - 1. Provide 1/4 inch (6.4 mm) more per side for a tight, compression fit.
 - 2. Cut sheet insulation with the following dimensions:
 - a. Width of duct plus 1/4 inch (6.4 mm), one piece.
 - b. Height of duct plus 1/4 inch (6.4 mm), plus thickness of insulation, two pieces.
 - c. Width of duct plus 1/4 inch (6.4 mm), plus two times the thickness of insulation, one piece.
 - 3. Insulate the bottom of the duct with the sheet from (a) above, then the sides with the two sheets from (b) above, and finally the top of the duct with the sheet from (c) above.
 - 4. Insulation without self-adhering backing:
 - a. Apply 100 percent coverage of manufacturer adhesive on the metal surface, then the insulation, except for the last 1/4 inch (6.4 mm) where sheets will butt together.
 - b. Roll sheet down into position.

- c. Press two sheets together under compression and apply adhesive at the butt joint to seal the two sheets together.
 5. Insulation with self-adhering backing:
 - a. Peel back release paper in 6- to 8-inch (150- to 203-mm) increments and line up sheet.
 - b. Press firmly to activate adhesive.
 - c. Align material and continue to line up correctly, pressing firmly while slowly removing release paper.
 - d. Allow 1/4-inch (6.4-mm) overlap for compression at butt joints.
 - e. Apply adhesive at the butt joint to seal the two sheets together.
 6. Insulate duct brackets following manufacturer's written installation instructions.
- D. Circular Ducts:
1. Determine the circumference of the duct, using a strip of insulation the same thickness as to be used.
 2. Cut the sheet to the required size.
 3. Apply 100 percent coverage of manufacturer adhesive on the metal surface then the insulation.
 4. Apply manufacturer adhesive to the cut surfaces along 100 percent of the longitudinal seam. Press together the seam at the ends and then the middle. Close the entire seam starting from the middle.
 - a. INSTALLATION OF MINERAL-FIBER INSULATION
- E. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. In first subparagraph below, many manufacturers do not recommend 100 percent coverage of adhesive because of the effect on the overall insulation system's fire-performance characteristics. Verify application coverage recommendations with insulation manufacturer.
 2. Apply adhesives according to manufacturer's recommended coverage rates per unit area.
 3. Revise first subparagraph below to allow adhesive to be omitted from top surface of horizontal rectangular ducts.
 4. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 5. 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 (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
 - b. On duct sides with dimensions larger than 18 inches (450 mm), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm)

- 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.
6. 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 (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-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 (10 deg C) at 18-foot (5.5-m) 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 (75 mm).
 7. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) o.c.
 8. 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.
 9. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.
- F. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. In first subparagraph below, many manufacturers do not recommend 100 percent coverage of adhesive because of the effect on the overall insulation system's fire-performance characteristics. Verify application coverage recommendations with insulation manufacturer.
 2. Apply adhesives according to manufacturer's recommended coverage rates per unit area. Revise first subparagraph below to allow adhesive to be omitted from top surface of horizontal rectangular ducts.
 3. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

4. 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 (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
 - b. On duct sides with dimensions larger than 18 inches (450 mm), space pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) 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.
5. 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 (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-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 (10 deg C) at 18-foot (5.5-m) 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 (75 mm).
6. 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.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

3.6 FIELD-APPLIED JACKET INSTALLATION

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 - 1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
 - 2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
 - 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- B. Where FSK jackets are indicated, install as follows:
 - 1. Draw jacket material smooth and tight.
 - 2. Install lap or joint strips with same material as jacket.
 - 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 - 4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
 - 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- C. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. 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.
- D. Where metal jackets are indicated, install with 2-inch (50-mm) 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 (300 mm) o.c. and at end joints.

3.7 FIRE-RATED INSULATION SYSTEM INSTALLATION

- A. Comply with manufacturer's written installation instructions.
- B. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
- C. Insulate duct access panels and doors to achieve same fire rating as duct.

- D. 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. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. 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 is limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
- D. 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, exposed, Type I, commercial, kitchen hood exhaust.
7. Indoor, concealed oven and warewash exhaust.
8. Indoor, exposed oven and warewash exhaust.
9. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
10. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
11. Outdoor, concealed supply and return.
12. Outdoor, exposed supply and return.

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 and flat-oval, supply-air duct insulation is one of the following:

1. Flexible Elastomeric: 1 inch (25 mm) thick.
2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5 lb/cu. ft. (24 kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
3. Mineral Fiber Blanket: 2 inches (50 mm) thick and 2 lb/cu. ft. (32 kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
4. Polyolefin: 1 inch (25 mm) thick.

B. Concealed, round and flat-oval, return-air duct insulation is one of the following:

1. Flexible Elastomeric: 1 inch (25 mm) thick.
2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5 lb/cu. ft. (24 kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
3. Mineral Fiber Blanket: 2 inches (50 mm) thick and 2 lb/cu. ft. (32 kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
4. Polyolefin: 1 inch (25 mm) thick.

C. Concealed, round and flat-oval, outdoor-air duct insulation is one of the following:

1. Flexible Elastomeric: 1 inch (25 mm) thick.
 2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 4. Polyolefin: 1 inch (25 mm) thick.
- D. Concealed, round and flat-oval, exhaust-air duct insulation is one of the following:
1. Flexible Elastomeric: 1 inch (25 mm) thick.
 2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 4. Polyolefin: 1 inch (25 mm) thick.
- E. Concealed, rectangular, supply-air duct insulation is one of the following:
1. Flexible Elastomeric: 1 inch (25 mm) thick.
 2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 4. Polyolefin: 1 inch (25 mm) thick.
- F. Concealed, rectangular, return-air duct insulation is one of the following:
1. Flexible Elastomeric: 1 inch (25 mm) thick.
 2. Mineral-Fiber Blanket: 2 inches (50 mm) Insert dimension thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 4. Polyolefin: 1 inch (25 mm) thick.
- G. Concealed, rectangular, outdoor-air duct insulation is one of the following:
1. Flexible Elastomeric: 1 inch (25 mm) thick.
 2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 4. Polyolefin: 1 inch (25 mm) thick.
- H. Concealed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior is one of the following:
1. Flexible Elastomeric: 1 inch (25 mm) thick.
 2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.

3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 4. Polyolefin: 1 inch (25 mm) thick.
- I. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket or board; thickness as required to achieve 2-hour fire rating.
- J. Concealed, supply-air plenum insulation is one of the following:
1. Flexible Elastomeric: 1 inch (25 mm) thick.
 2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 4. Polyolefin: 1 inch (25 mm) thick.
- K. Concealed, return-air plenum insulation is one of the following:
1. Flexible Elastomeric: 1 inch (25 mm) thick.
 2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 4. Polyolefin: 1 inch (25 mm) thick.
- L. Concealed, outdoor-air plenum insulation is one of the following:
1. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
- M. Concealed, exhaust-air plenum insulation is one of the following:
1. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
- N. Exposed, round and flat-oval, supply-air duct insulation is one of the following:
1. Flexible Elastomeric: 1 inch (25 mm) thick.
 2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 4. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
 5. Polyolefin: 1 inch (25 mm) thick.
- O. Exposed, round and flat-oval, return-air duct insulation is one of the following:

1. Flexible Elastomeric: 1 inch (25 mm) thick.
 2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 4. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
 5. Polyolefin: 1 inch (25 mm) thick.
- P. Exposed, round and flat-oval, outdoor-air duct insulation is one of the following:
1. Flexible Elastomeric: 1 inch (25 mm) thick.
 2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 4. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
 5. Polyolefin: 1 inch (25 mm) thick.
- Q. Exposed, round and flat-oval, exhaust-air duct insulation is one of the following:
1. Flexible Elastomeric: 1 inch (25 mm) thick.
 2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 4. Mineral-Fiber Pipe and Tank: 1-1/2 inches (38 mm) thick.
 5. Polyolefin: 1 inch (25 mm) thick.
- R. Exposed, rectangular, supply-air duct insulation is one of the following:
1. Flexible Elastomeric: 1 inch (25 mm) thick.
 2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 4. Polyolefin: 1 inch (25 mm) thick.
- S. Exposed, rectangular, return-air duct insulation is one of the following:
1. Flexible Elastomeric: 1 inch (25 mm) thick.
 2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 4. Polyolefin: 1 inch (25 mm) thick.
- T. Exposed, rectangular, outdoor-air duct insulation is one of the following:
1. Flexible Elastomeric: 1 inch (25 mm) thick.

2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 4. Polyolefin: 1 inch (25 mm) thick.
- U. Exposed, rectangular, exhaust-air duct insulation is one of the following:
1. Flexible Elastomeric: 1 inch (25 mm) thick.
 2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 4. Polyolefin: 1 inch (25 mm) thick.
- V. Exposed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket or board; thickness as required to achieve 2-hour fire rating.
- W. Exposed, supply-air plenum insulation shall be one of the following:
1. Flexible Elastomeric: 1 inch (25 mm) thick.
 2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 4. Polyolefin: 1 inch (25 mm) thick.
- X. Exposed, return-air plenum insulation shall be one of the following:
1. Flexible Elastomeric: 1 inch (25 mm) thick.
 2. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 3. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 4. Polyolefin: 1 inch (25 mm) thick.
- Y. Exposed, outdoor-air plenum insulation shall be one of the following:
1. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
- Z. Exposed, exhaust-air plenum insulation shall be one of the following:
1. Mineral-Fiber Blanket: 2 inches (50 mm) thick and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.
 2. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 6 (hr.ft².F)/Btu.

3.12 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.
- B. Concealed, round and flat-oval, supply-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 3 inches (75 mm) and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
 - 2. Mineral-Fiber Board: 3 inches (75 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
- C. Concealed, round and flat-oval, return-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 3 inches (75 mm) and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
 - 2. Mineral-Fiber Board: 3 inches (75 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
- D. Concealed, round and flat-oval, outdoor-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 3 inches (75 mm) and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
 - 2. Mineral-Fiber Board: 3 inches (75 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
- E. Concealed, rectangular, supply-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 3 inches (75 mm) and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
 - 2. Mineral-Fiber Board: 3 inches (75 mm) thick and 2-lb/cu. ft. (96-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
- F. Concealed, rectangular, return-air duct insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 3 inches (75 mm) and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
 - 2. Mineral-Fiber Board: 3 inches (75 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
- G. Concealed, supply-air plenum insulation shall be one of the following:
 - 1. Mineral-Fiber Blanket: 3 inches (75 mm) and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
 - 2. Mineral-Fiber Board: 3 inches (75 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
- H. Concealed, return-air plenum insulation shall be one of the following:

1. Mineral-Fiber Blanket: 3 inches (75 mm) and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
 2. Mineral-Fiber Board: 3 inches (75 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
- I. Exposed, round and flat-oval, supply-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 3 inches (75 mm) and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
 2. Mineral-Fiber Board: 3 inches (75 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
 3. Mineral-Fiber Pipe and Tank: 3 inches (75 mm) thick. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
- J. Exposed, round and flat-oval, return-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 3 inches (75 mm) and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
 2. Mineral-Fiber Board: 3 inches (75 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
- K. Exposed, rectangular, supply-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 3 inches (75 mm) and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
 2. Mineral-Fiber Board: 3 inches (75 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
- L. Exposed, rectangular, return-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 3 inches (75 mm) and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
 2. Mineral-Fiber Board: 3 inches (75 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
- M. Exposed, supply-air plenum insulation shall be one of the following:
1. Mineral-Fiber Blanket: 3 inches (75 mm) and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
 2. Mineral-Fiber Board: 3 inches (75 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
- N. Exposed, return-air plenum insulation shall be one of the following:
1. Mineral-Fiber Blanket: 3 inches (75 mm) and 1.5-lb/cu. ft. (24-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.
 2. Mineral-Fiber Board: 3 inches (75 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) nominal density. Installed minimum R-Value = 12 (hr.ft².F)/Btu.

3.13 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. PVC: 30 mils (0.8 mm) thick.
 - 2. Aluminum, Smooth: 0.024 inch (0.61 mm) thick.
- D. Ducts and Plenums, Exposed:
 - 1. PVC: 30 mils (0.8 mm) thick.
 - 2. Aluminum, Smooth: 0.024 inch (0.61 mm) thick.

3.14 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. Ducts and Plenums, Concealed:
 - 1. None.
 - 2. PVC: 30 mils (0.8 mm) thick.
 - 3. Aluminum, Smooth: 0.024 inch (0.61 mm) thick.
- D. Ducts and Plenums, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
 - 1. Aluminum, Smooth: 0.024 inch (0.61 mm) thick.
 - 2. Painted Aluminum, Smooth: 0.024 inch (0.61 mm) thick.
- E. Ducts and Plenums, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
 - 1. Aluminum, Smooth with 2-1/2-Inch- (65-mm-) Deep Corrugations: 0.032 inch (0.81 mm) thick.

END OF SECTION

SECTION 23 07 16

HVAC EQUIPMENT INSULATION

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes insulating HVAC equipment that is not factory insulated.
- B. Related Sections:
 - 1. Section 230713 "Duct Insulation."
 - 2. Section 230719 "HVAC Piping Insulation."

1.2 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 removable insulation at equipment connections.
 - 2. Detail application of field-applied jackets.
 - 3. Detail application at linkages of control devices.
 - 4. Detail field application for each equipment type.
- C. 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 (300 mm) square.
 - 2. Sheet Jacket Materials: 12 inches (300 mm) 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.

1.3 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.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program, certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.
 - 1. Equipment Mockups:
 - a. One chilled-water pump and one heating-hot-water pump.
 - b. One tank or vessel.
 - 2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
 - 3. Notify Architect seven days in advance of dates and times when mockups will be constructed.
 - 4. Obtain Architect's approval of mockups before starting insulation application.
 - 5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 - 6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 - 7. Demolish and remove mockups when directed.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation system materials are to be delivered to the Project site in unopened containers. The packaging is to include, the name of the manufacturer, fabricator, type, description, and size, as well as ASTM standard designation, and maximum use temperature.

1.6 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 equipment Installer for equipment insulation application.
- C. Coordinate installation and testing of heat tracing.

1.7 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.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. 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, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.
 - 1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2.
 - 3. All Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

2.2 INSULATION MATERIALS

- A. Comply with requirements in "Breeching Insulation Schedule," "Indoor Equipment Insulation Schedule," and "Outdoor, Aboveground Equipment Insulation Schedule" articles for where insulating materials are applied.
 - B. Products do not contain asbestos, lead, mercury, or mercury compounds.
 - C. Products that come in contact with stainless steel 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 are qualified as acceptable in accordance with ASTM C795.
 - E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.
 - F. Calcium Silicate: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C533, Type I or Type II.
- 1. Prefabricated Fitting Covers: Comply with ASTM C450 and ASTM C585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
 - a. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1) Johns Manville; a Berkshire Hathaway company.
 - 2) ITW Insulation Systems
 - 3) RPR Products
 - b. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Comply with ASTM C552.
 - 2. Manufacturers: Subject to compliance with requirements, **provide products by the following**
 - a. Owens Corning.
 - b. Extol of Ohio
 - c. GLT Products
 - 3. Block Insulation: Type I.
 - 4. Special-Shaped Insulation: Type III.
 - 5. Board Insulation: Type IV.
 - 6. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
 - 7. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

- G. Flexible Elastomeric: Closed-cell or expanded-rubber materials; suitable for maximum use temperature between minus 70 deg F (minus 57 deg C) and 220 deg F (104 deg C). Comply with ASTM C534/C534M, Type II for sheet materials.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- a. Aeroflex USA.
 - b. Armacell LLC.
 - c. K-Flex USA.
- H. Glass-Fiber Blanket: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 450 deg F (232 deg C) in accordance with ASTM C411. Comply with ASTM C553, Type II, and ASTM C1290, 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 the following:**
- a. CertainTeed; SAINT-GOBAIN.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
- I. Glass-Fiber Board: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature between 35 deg F (1.7 deg C) and 250 deg F (121 deg C) for jacketed and between 35 deg F (1.7 deg C) and 450 deg F (232 deg C) for unfaced in accordance with ASTM C411. Comply with ASTM C612, Type IA or Type IB. Provide insulation 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; SAINT-GOBAIN.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Manson Insulation Inc.
 - e. Owens Corning.
- J. Glass-Fiber, Pipe and Tank: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature between 35 deg F (1.7 deg C) and 850 deg F (454 deg C), in accordance with ASTM C411. Comply with ASTM C1393.
1. Manufacturers: Subject to compliance with requirements, **provide products by one of the following:**
- a. CertainTeed; SAINT-GOBAIN.

- b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Owens Corning.
 - 2. Semirigid board material with factory-applied ASJ jacket.
 - 3. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- K. Polyisocyanurate: Prefabricated, rigid cellular polyisocyanurate material intended for use as thermal insulation. Comply with ASTM C591.
- 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. Duna-USA
 - c. Dyplast Products
 - 2. Type I or Type IV, except thermal conductivity (k-value) does not exceed 0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K) at 75 deg F (24 deg C) after 180 days of aging.
 - 3. Flame-spread index is 25 or less and smoke-developed index is 50 or less for thicknesses of up to 1.5 inches (38 mm) as tested in accordance with ASTM E84.
 - 4. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
 - 5. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
 - a. Polyolefin: Polyethylene thermal plastic insulation. Comply with ASTM C1427, Type II, Grade 1 for sheet materials.
 - 6. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Armacell LLC.
 - b. Sekisui Voltek
 - c. Nomaco
- L. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C578, Type IV or VIII.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Dow Chemical Co., sold through Polyguard Products, Inc.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Owens Corning
 - 2. Fabricate shapes in accordance with ASTM C450 and ASTM C585.

2.3 INSULATING CEMENTS

- A. Glass-Fiber and Mineral Wool Insulating Cement: Comply with ASTM C195.
 - 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. Ramco Insulation, Inc.
 - b. Johns Manville
 - c. Morgan Thermal Ceramics
- B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C196.
 - 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. Ramco Insulation, Inc.
 - b. Johns Manville
 - c. Morgan Thermal Ceramics
- C. Glass-Fiber and Mineral Wool, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.
 - 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. Ramco Insulation, Inc.
 - b. Johns Manville
 - c. Morgan Thermal Ceramics

2.4 ADHESIVES

- A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F (10 to 427 deg C).
 - 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.

- c. Mon-Eco Industries, Inc.
 - d. Vimasco Corporation.
- C. 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 (minus 73 to plus 93 deg C).
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller.
 - c. Owens Corning
- D. Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F (minus 59 to plus 149 deg C).
 - 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.
 - c. Owens Corning
- E. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA.
 - b. Armacell LLC.
 - c. K-Flex USA.
 - 2. Flame-spread index is 25 or less and smoke-developed index is 50 or less as tested in accordance with ASTM E84.
 - 3. Wet Flash Point: Below 0 deg F (minus 18 deg C)
 - 4. Service Temperature Range: 40 to 200 deg F (4 to plus 93 deg C).
 - 5. Color: Black.
- F. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller.
 - c. Mon-Eco Industries, Inc.

- G. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F (29 to plus 60 deg C).
 - 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.
 - c. Owens Corning
- H. 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 the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller.
 - c. Mon-Eco Industries, Inc.
- I. PVC Jacket Adhesive: Compatible with PVC jacket.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. P.I.C. Plastics, Inc.
 - c. Proto Corporation.
 - d. Speedline Corporation.
 - e. The Dow Chemical Company.

2.5 MASTICS AND COATINGS

- A. Materials are compatible with insulation materials, jackets, and substrates.
- B. Vapor-Retarder Mastic, Water Based: Suitable for indoor and outdoor 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.
 - c. Knauf Insulation.
 - d. Mon-Eco Industries, Inc.
 - e. Vimasco Corporation.
 - 2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.

3. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
 4. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.
 5. Color: White.
- C. Vapor-Retarder Mastic, Solvent Based, Indoor Use: Suitable for indoor use on below-ambient services.
1. Manufacturers: Subject to compliance with requirements, **provide products by the following:**
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller.
 - c. Mon-Eco Industries, Inc.
 2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 3. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
 4. Color: White.
- D. Vapor-Retarder Mastic, Solvent Based, Outdoor Use: Suitable for outdoor 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.
 - c. Mon-Eco Industries, Inc.
 2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 3. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
 4. Color: White.
- E. 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. Foster Brand; H. B. Fuller.
 - c. Knauf Insulation.
 - d. Mon-Eco Industries, Inc.
 - e. Vimasco Corporation.
 2. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm (0.66 metric perms) at manufacturer's recommended dry film thickness.
 3. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).

4. Color: White.

2.6 LAGGING ADHESIVES

- A. Adhesives comply with MIL-A-3316C, Class I, Grade A and are compatible with insulation materials, jackets, and substrates.
 1. **Manufacturers:** Subject to compliance with requirements, **provide products by the following:**
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller.
 - c. Vimasco Corporation.
 2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment insulation.
 3. Service Temperature Range: 20 to plus 180 deg F (Minus 6 to plus 82 deg C).
 4. Color: White.

2.7 SEALANTS

- A. Materials are as recommended by the insulation manufacturer and are compatible with insulation materials, jackets, and substrates.
- B. 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. Foster Brand; H. B. Fuller.
 - c. Mon-Eco Industries, Inc.
 - d. Owens Corning.
 2. Permanently flexible, elastomeric sealant.
 3. Service Temperature Range: Minus 58 to plus 176 deg F (Minus 50 to plus 80 deg C).
 4. Color: White or gray.
- C. 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. Foster Brand; H. B. Fuller.

- c. Mon-Eco Industries, Inc.
 2. Fire- and water-resistant, flexible, elastomeric sealant.
 3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 4. Color: Aluminum.
- D. ASJ Flashing Sealants and Vinyl, PVDC, and PVC 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. Foster Brand; H. B. Fuller.
 - c. Owens Corning
 2. Fire- and water-resistant, flexible, elastomeric sealant.
 3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 4. Color: White.

2.8 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 C1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
 4. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested in accordance with ASTM E96/E96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.9 FIELD-APPLIED JACKETS

- A. Field-applied jackets comply with ASTM C1136, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. P.I.C. Plastics, Inc.
 - c. Proto Corporation.
 - d. Speedline Corporation.
2. Adhesive: As recommended by jacket material manufacturer.
3. Color: Color-code jackets based on system. Color as selected by Architect.
4. Factory-fabricated tank heads and tank side panels.

D. Metal Jacket:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. RPR Products, Inc.
 - c. Ideal Products
2. Aluminum Jacket: Comply with ASTM B209 (ASTM B209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Sheet and roll stock ready for shop or field sizing.
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
 - d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
 - e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed two-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.
3. Stainless Steel Jacket: ASTM A240/A240M.
 - a. Sheet and roll stock ready for shop or field sizing.
 - b. Material, finish, and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.

- d. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
- e. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed two-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.
- E. Self-Adhesive Outdoor Jacket (Asphaltic): 60-mil- (1.5-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with white or stucco-embossed aluminum-foil facing.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. MFM Building Products Corp.
 - b. Polyguard Products, Inc.
 - c. 3M / Venture Tape
- F. Self-Adhesive Indoor/Outdoor Jacket (Non-Asphaltic): Vapor barrier and waterproofing jacket for installation over insulation located aboveground outdoors or indoors. Specialized jacket has five layers of laminated aluminum and polyester film with low-temperature acrylic pressure-sensitive adhesive. Outer aluminum surface is coated with UV-resistant coating for protection from environmental contaminants.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M.
 - b. Foster Brand; H. B. Fuller.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - 2. Permeance: 0.00 perm as tested in accordance with ASTM F1249.
 - 3. Flamespread/Smoke Developed: 25/50 as tested in accordance with ASTM E84.
 - 4. Aluminum Finish: Embossed.

2.10 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass-Fiber Mesh: Approximately 4 oz./sq. yd. (114 g/sq. m) with a thread count of 5 strands by 5 strands/sq. in. (2 strands by 2 strands/sq. mm) for covering equipment.
 - 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.
 - c. Johns Manville
- B. Woven Polyester Mesh: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for equipment.
 - 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.
 - c. Vimasco Corporation.

2.11 FIELD-APPLIED CLOTHS

- A. Woven Glass-Fiber Cloth: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Alpha Associates, Inc.
 - b. Auburn Manufacturing Inc.
 - c. Amatex

2.12 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.

- c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 2. Width: 3 inches (75 mm).
 3. Thickness: 11.5 mils (0.29 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) 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 C1136.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
 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. 3M Industrial Adhesives and Tapes Division.
 - b. Ideal Tape Co., Inc., an American Biltrite Company.
 - c. Johns Manville
 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. 3M Industrial Adhesives and Tapes Division.
 - b. Avery Dennison Corporation, Specialty Tapes Division.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Knauf Insulation.
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.

2.13 SECUREMENTS

A. Bands:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. RPR Products, Inc.
 - c. GEMCO.
2. Stainless Steel: ASTM A240/A240M, **Type 304 or Type 316**; 0.015 inchthick, **1/2 inch** wide with**closed seal**.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size is 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; **0.106-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) Midwest Fasteners, Inc.
 - 4) Nelson Stud Welding.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding; **0.106-inch**-diameter

shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) 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) Midwest Fasteners, Inc.
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.
 - 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 (0.76 mm) thick by 2 inches (50 mm) square.
 - c. Spindle: **Stainless steel**, fully annealed, 0.106-inch- (2.6-mm-) diameter shank; length to suit depth of insulation indicated.
 - d. Adhesive: Recommended by hanger manufacturer. Use 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.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Gemco.
 - 2) Midwest Fasteners, Inc.
 - 3) Duro Dyne
 - b. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
 - c. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank; length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
 - d. Adhesive: Recommended by hanger manufacturer. Use 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.
 - 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: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - c. Spindle: **Stainless steel**, fully annealed; 0.106-inch- (2.6-mm-) 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- (0.41-mm-) thick, **stainless steel** sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - 4) 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- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
- D. Wire: **062-inch (1.6-mm) soft-annealed, stainless steel**
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. C & F Wire Products.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. RPR Products, Inc.

2.14 CORNER ANGLES

- A. Stainless Steel Corner Angles: **0.024-inch-thick**, minimum 1- by 1-inch stainless steel in accordance with ASTM A240/A240M, **Type 304 or Type 316**.

PART 3 - EXECUTION

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 and equipment 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 (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range of between 140 and 300 deg F (60 and 149 deg C). 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 (0 and 149 deg C) 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 equipment.
- B. Install insulation materials, forms, vapor barriers or retarders, and jackets, of thicknesses required for each item of equipment, as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.
- 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 storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with the Contract Documents, **unless otherwise approved by the engineer-of-record.**
- 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 attached 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 insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

- 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, but not to the extent of creating wrinkles or areas of compression in the insulation.
 - 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at **2 inches** o.c.
 - 4. For below-ambient services, apply vapor-barrier mastic over staples.
 - 5. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
 - 6. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.
- L. Cut insulation in a manner to avoid compressing insulation.
- 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 (100 mm) beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.
- O. 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 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

- A. **Glass-Fiber**, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive, anchor pins, and speed washers.

1. Apply adhesives in accordance with manufacturer's recommended coverage rates per unit area, for **100** percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
 - a. Do not weld anchor pins to ASME-labeled pressure vessels.
 - b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - c. On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints and 16 inches (400 mm) o.c. in both directions.
 - d. Do not compress insulation during installation.
 - e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
 - f. Impale insulation over anchor pins, and attach speed washers.
 - g. 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.
5. Secure each layer of insulation with stainless steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches (75 mm).
8. Install insulation in removable and replaceable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.

10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.
- B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
 1. Apply **100** percent coverage of adhesive to surface with manufacturer's recommended adhesive.
 2. Seal longitudinal seams and end joints.
- C. Insulation Installation on Pumps:
 1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a field-adjustable latching mechanism.
 2. Fabricate boxes from **stainless steel**, at least **0.040 inch** thick.
 3. For below-ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.5 INSTALLATION OF CALCIUM SILICATE INSULATION

- A. Insulation Installation on Boiler Breechings:
 1. Secure single-layer insulation with stainless steel bands at 12-inch (300-mm) intervals, and tighten bands without deforming insulation material.
 2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless steel bands at 12-inch (300-mm) intervals.
 3. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. Install in accordance with manufacturer's written installation instructions and ASTM C1710.

- B. 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.

3.7 FIELD-APPLIED JACKET INSTALLATION

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 - 1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
 - 2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
 - 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- B. Where FSK jackets are indicated, install as follows:
 - 1. Draw jacket material smooth and tight.
 - 2. Install lap or joint strips with same material as jacket.
 - 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 - 4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
 - 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- C. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. 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.
- D. Where metal jackets are indicated, install with 2-inch (50-mm) 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 (300 mm) o.c. and at end joints.
- E. Where PVDC jackets are indicated, install as follows:

1. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches (850 mm) or less. 33-1/2-inch- (850-mm-) circumference limit allows for 2-inch- (50-mm-) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
2. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.8 FINISHES

- A. Equipment 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. 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 field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection is limited to **one** location(s) for each type of equipment defined in "Indoor Equipment Insulation Schedule" and "Outdoor, Aboveground Equipment Insulation Schedule" articles. For large equipment, remove only a portion adequate to determine compliance.
- F. All insulation applications will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports.

3.10 EQUIPMENT INSULATION SCHEDULE, GENERAL

- A. Insulation conductivity and thickness per pipe size comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.
- B. Acceptable 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 is Contractor's option.

3.11 INDOOR EQUIPMENT INSULATION SCHEDULE

- A. Insulate indoor and outdoor equipment that is not factory insulated.
- B. Heating-hot-water pump insulation is the following:
 - 1. Cellular Glass: 3 inches thick.
- C. Heating-hot-water expansion/compression tank insulation is the following:
 - 1. Cellular Glass: **2 inches (50 mm)** thick.
- D. Heating-hot-water air-separator insulation is the following:
 - 1. Cellular Glass: **3 inches** thick.

3.12 OUTDOOR, ABOVEGROUND EQUIPMENT INSULATION SCHEDULE

- A. Retain "one of" option in paragraph below to allow Contractor to select materials from those retained. Heated, fuel-oil storage tank insulation is the following:

1. Cellular Glass: **3 inch** thick.

3.13 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. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces of up to 72 Inches (1800 mm):
 1. Stainless Steel, **Type 304 or Type 316, Smooth No. 2B Finish: 0.010 inch (0.25 mm)** thick.
- D. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
 1. Stainless Steel, **Type 304 or Type 316, Smooth, with 1-1/4-Inch- (32-mm-) Deep Corrugations: 0.020 inch** thick.

END OF SECTION

SECTION 23 07 19

HVAC PIPING INSULATION

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes insulation for HVAC piping systems.
- B. Related Requirements:
 - 1. Section 230713 "Duct Insulation" for duct insulation.
 - 2. Section 230716 "HVAC Equipment Insulation" for equipment insulation.
 - 3. Section 232113.13 "Underground Hydronic Piping" loose-fill pipe insulation in underground piping outside the building.
 - 4. Section 232213.13 "Underground Steam and Condensate Heating Piping" for steam and condensate piping for steam-type tank heaters.

1.2 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).

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.
- B. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.
1. Preformed Pipe Insulation Materials: 12 inches (300 mm) long by NPS 2 (DN 50).
 2. Sheet Form Insulation Materials: 12 inches (300 mm) square.
 3. Jacket Materials for Pipe: 12 inches (300 mm) long by NPS 2 (DN 50).
 4. Sheet Jacket Materials: 12 inches (300 mm) square.
 5. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.3 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.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or craft training program, certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.
1. Piping Mockups:
 - a. One 10-foot (3-m) section of NPS 2 (DN 50) straight pipe.
 - b. One each of a 90-degree threaded, welded, and flanged elbow.
 - c. One each of a threaded, welded, and flanged tee fitting.

- d. One NPS 2 (DN 50) or smaller valve and one NPS 2-1/2 (DN 65) or larger valve.
 - e. Four support hangers, including hanger shield and insert.
 - f. One threaded strainer and one flanged strainer with removable portion of insulation.
 - g. One threaded reducer and one welded reducer.
 - h. One pressure temperature tap.
 - i. One mechanical coupling.
 - j. One union.
- 2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
 - 3. Notify Engineer seven days in advance of dates and times when mockups will be constructed.
 - 4. Obtain Engineer's approval of mockups before starting insulation application.
 - 5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Engineer specifically approves such deviations in writing.
 - 6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 - 7. Demolish and remove mockups when directed.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation system materials are to be delivered to the Project site in unopened containers. The packaging is to include name of manufacturer, fabricator, type, description, and size, as well as ASTM standard designation, and maximum use temperature.

1.6 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.

1.7 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.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. 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 authority having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.
 - 1. All Insulation Installed Indoors and Outdoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2.2 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 are applied.
- B. Products do not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come into contact with stainless steel 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 are qualified as acceptable in accordance with ASTM C795.
- E. Foam insulation materials do not use CFC or HCFC blowing agents in the manufacturing process.
- F. Flexible Elastomeric: Closed-cell, or expanded-rubber materials; suitable for maximum use temperature between minus 70 deg F (minus 57 deg C) and 220 deg F (104 deg C). Comply with ASTM C534/C534M, Type I, for tubular materials, Type II for sheet materials.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA.
 - b. Armacell LLC.
 - c. K-Flex USA.
- G. Glass-Fiber, Preformed Pipe: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 850 deg F (454 deg C) in accordance with ASTM C411. Comply with ASTM C547.
 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. Preformed Pipe Insulation: Type I, Grade A with factory-applied ASJ+ jacket.
 3. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
 4. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.3 INSULATING CEMENTS

- A. Glass-Fiber and Mineral Wool Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville.
 - b. ITW Insulation Systems.
 - c. K-Flex USA.

2.4 ADHESIVES

- A. Materials are 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: Solvent-based adhesive.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Aeroflex USA.
 - b. Armacell LLC.
 - c. K-Flex USA.
 2. Flame-spread index is 25 or less and smoke-developed index is 50 or less as tested in accordance with ASTM E84.
 3. Wet Flash Point: Below 0 deg F (minus 18 deg C).
 4. Service Temperature Range: 40 to 200 deg F (4 to plus 93 deg C).
 5. Color: Black
- C. PVC Jacket Adhesive: Compatible with PVC jacket.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. P.I.C. Plastics, Inc.
 - c. Proto Corporation.
 - d. Sekisui Voltek, LLC.
 - e. Speedline Corporation.
 - f. The Dow Chemical Company.

2.5 MASTICS AND COATINGS

- A. Materials are compatible with insulation materials, jackets, and substrates.
- B. Vapor-Retarder 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.
 - c. Knauf Insulation.
 2. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C)
 4. Retain MIL-PRF-19565C in first subparagraph below for vapor-retarder mastics and coatings if applicable to Project.
 5. Comply with MIL-PRF-19565C, Type II, for permeance requirements, with supplier listing on DOD QPD - Qualified Products Database.
 6. 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. Foster Brand; H. B. Fuller.
 - c. Knauf Insulation.
 - d. Mon-Eco Industries, Inc.
 - e. Vimasco Corporation.
2. Water-Vapor Permeance: ASTM E96/E96M, greater than 1.0 perm (0.66 metric perm) at manufacturer's recommended dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C)
4. Color: White

2.6 LAGGING ADHESIVES

- A. Adhesives comply with MIL-A-3316C, Class I, Grade A, and are compatible with insulation materials, jackets, and substrates.
 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.
 - c. Vimasco Corporation.
 2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C)
 4. Color: White.

2.7 SEALANTS

- A. Materials are as recommended by the insulation manufacturer and are compatible with insulation materials, jackets, and substrates.
- 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. Foster Brand; H. B. Fuller.

- c. Mon-Eco Industries, Inc.
 - 2. Fire- and water-resistant, flexible, elastomeric sealant.
 - 3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 - 4. Color: Aluminum.
- C. ASJ Flashing Sealants and PVDC and PVC 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. Foster Brand; H. B. Fuller.
 - c. Hardcast, Carlisle HVAC Products.
 - 2. Fire- and water-resistant, flexible, elastomeric sealant.
 - 3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 - 4. Color: White.

2.8 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 C1136, Type I.
 - 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C1136, Type I.
 - 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
 - 4. ASJ+: Aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C1136, Types I, II, III, IV, and VII.
 - 5. PSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C1136, Type II.

2.9 FIELD-APPLIED JACKETS

- A. Metal Jacket:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. RPR Products, Inc.
 - c. ITW Insulation Systems
2. Stainless Steel Jacket: ASTM A240/A240M.
 - a. Sheet and roll stock ready for shop or field sizing.
 - b. Material, finish, and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Outdoor Applications: 53-mil- (0.075-mm-) thick polysurlyn.
 - d. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed two-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.

2.10 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M Industrial Adhesives and Tapes Division.
 - b. Aeroflex USA.
 - c. Avery Dennison Corporation, Specialty Tapes Division.
 - d. Ideal Tape Co., Inc., an American Biltrite Company.
 - e. Knauf Insulation.

2. Width: 3 inches (75 mm)
3. Thickness: 11.5 mils (0.29 mm)
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) > in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

2.11 SECUREMENTS

A. Bands:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. RPR Products, Inc.
 - c. ITW Insulation Systems
2. Stainless Steel: ASTM A240/A240M, Type 316; 0.015 inch (0.38 mm) thick, 3/4 inch (19 mm) wide with wing seal.

B. Staples: Outward-clinching insulation staples, nominal 3/4 inch (19 mm) wide, stainless steel or Monel.

C. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. C & F Wire Products.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. RPR Products, Inc.

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 (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). 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 (0 and 149 deg C) 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, compress, or otherwise damage insulation or jacket.
- D. Install insulation with longitudinal seams at top and bottom (12 o'clock and 6 o'clock positions) 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 during storage or in the installation process before being properly covered and sealed in accordance with the Contract Documents, unless otherwise approved by the engineer of record.
- 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, but not to the extent of creating wrinkles or areas of compression in the insulation.
 - 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). 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 (50 mm) o.c.
 - 4. For below-ambient services, apply vapor-barrier mastic over staples.

- 5. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
- 6. 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.
- 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 (100 mm) 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.

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 (50 mm) 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 (50 mm).
 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 below.
- 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 prefabricated fitting insulation or mitered or routed fittings made from same material and density as that of adjacent pipe insulation. Each piece is 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 prefabricated fitting insulation or mitered or routed fittings 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 prefabricated fitting insulation or mitered or routed fittings 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 prefabricated fitting insulation or mitered or routed fittings 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. 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 to fit. 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 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 conforms 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 (50 mm) 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 that of 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 sections of pipe insulation and miter if required in accordance with manufacturer's written instructions.
 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 prefabricated valve covers manufactured of same material as that of pipe insulation when available.
2. When prefabricated 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 GLASS-FIBER AND MINERAL WOOL 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 jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
4. For insulation with 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 prefabricated 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 glass-fiber or mineral-wool blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install prefabricated sections of same material as that of 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 prefabricated sections of same material as that of straight segments of pipe insulation when available.
2. When prefabricated sections are not available, install fabricated 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 INSTALLATION OF FIELD-APPLIED JACKETS

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated and for horizontal applications, install with 1-inch (25-mm) overlap at longitudinal seams and end joints. 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.

D. Where metal jackets are indicated, install with 2-inch (50-mm) 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 (300 mm) o.c. and at end joints.

E. Where PVDC jackets are indicated, install as follows:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap presized jackets around individual pipe insulation sections, with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches (50 mm) over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral-wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches (850 mm) or less. The 33-1/2-inch- (850-mm-) circumference limit allows for 2-inch- (50-mm-) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.9 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.

3.10 FIELD QUALITY CONTROL

- A. Owner will engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections with the assistance of a factory-authorized service representative.
- C. 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 is 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.
- D. All insulation applications will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.11 PIPING INSULATION SCHEDULE, GENERAL

- A. Insulation conductivity and thickness per pipe size comply with schedules in this Section or with requirements of authorities having jurisdiction, whichever is more stringent.
- B. 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.
- C. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Underground piping.
 - 2. 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 below 60 Deg F (16 Deg C):
 - 1. All Pipe Sizes: Insulation is the following:
 - a. Flexible Elastomeric: 3/4 inch thick.
- B. Heating-Hot-Water Supply and Return, 200 Deg F (93 Deg C) and Below:

1. NPS 1 and Smaller: Insulation is the following:
 - a. Glass-Fiber, Preformed Pipe, Type I: 1.5 inch
 2. NPS 1-1/2 and Larger: Insulation is the following:
 - a. Glass-Fiber: 2 inches thick.
- C. Refrigerant Suction and Hot-Gas Piping:
1. All Pipe Sizes: Insulation is the following:
 - a. Flexible Elastomeric: 1.5 inch thick.
- D. Refrigerant Suction and Hot-Gas Flexible Tubing:
1. All Pipe Sizes: Insulation is one of the following:
 - a. Flexible Elastomeric: 2 inches thick.
- E. Refrigerant Liquid Piping:
1. All Pipe Sizes: Insulation is the following:
 - a. Flexible Elastomeric: 1 inch thick.

3.13 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

- A. Heating-Hot-Water Supply and Return, 200 Deg F (93 Deg C) and Below:
1. All Pipe Sizes: Insulation is one of the following:
 - a. Glass-Fiber: 2 inches thick.
- B. Refrigerant Suction and Hot-Gas Piping:
1. All Pipe Sizes: Insulation is the following:
 - a. Flexible Elastomeric: 2 inches thick.
- C. Refrigerant Suction and Hot-Gas Flexible Tubing:
1. All Pipe Sizes: Insulation is the following:
 - a. Flexible Elastomeric: 2 inches thick.
- D. Refrigerant Liquid Piping:
1. All Pipe Sizes: Insulation is the following:
 - a. Flexible Elastomeric: 1 inch thick.
- E. Fuel Oil Piping, Heated:
1. All Pipe Sizes: Insulation is the following:
 - a. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

3.14 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. Stainless Steel, Type 316, Smooth No. 2B Finish: 0.010 inch thick.
- D. Piping, Exposed:
 - 1. Stainless Steel, Type 316, Smooth No. 2B Finish: 0.010 inch thick.

END OF SECTION

SECTION 23 09 23

DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 CONDITIONS & REQUIREMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections apply to this Section.
- B. All work shall comply with the requirements of the Conditions of the Contract (General and Special), with the Contract Drawings, and with all other contract documents.
- C. Any deviations from the requirements of the Contract Documents must be submitted in writing along with bid documents.

1.2 RELATED DOCUMENTS

- A. In case there is a discrepancy between this specification and Division 21, Division 22, Division 23, Division 26 and Division 28 specifications and their associated drawings, then the Bidder shall assume the more stringent requirement for his bid.

1.3 SUMMARY

- A. Section Includes:
 - 1. DDC 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.

1.4 SCOPE OF WORK

- A. Control Contractor shall:
 - 1. Provide installations of controllers and instruments provided by system and device manufacturers for equipment monitoring and control as herein specified. The scope shall include controllers, microprocessor-based controller unit panels, instrumentation, end control devices, wiring, conduit, and related systems integration as follows:
 - a. Dedicated Outside Air Units
 - b. Supply / Exhaust Fans

DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

- c. Electric Unit Heaters
 - d. DX Split Systems
 - e. Air Handling Units (AHU)
 - f. Exhaust Fans
 - g. Roof Mounted Water Tank System
 - h. Heating Hot Water System
 - i. Water Meters
 - j. Programmed Start-Stop of Systems
 - k. Monitoring and controlling of Space Conditions
 - l. Alarm Annunciation.
- 2. Provide a required DDC control system hardware along with sensing devices, control valves, dampers and actuators as specified herein.
 - 3. Provide a complete operational system including all work specified herein, specified in associated specifications for mechanical and electrical work and shown on all contract drawings.
 - 4. The Contractor shall assume all control points referred to in this specification as well as the specifications in Division 23 and Division 26. The contractor is also responsible for all instrumentation and controls shown on the controls drawings, Division 23 and Division 26 drawings.
 - 5. The BMS system shall provide equipment supervision and control, alarm management, energy management, information management, historical data collection and archiving and be capable of integrating multiple building functions.
 - 6. The system shall employ standard networking practices and conventions, co-exist with existing Ethernet networks, and manage system data using generally accepted database storage and retrieval methods and standards.
 - 7. Provide all wiring, raceways and electrical work associated with the BMS. This shall include and to be limited to the following:
 - a. Controls wiring and conduit between control panels.
 - b. Controls wiring and conduit between control panels and field instrumentation, external equipment control systems
 - c. Wiring and conduit for the BMS communication networks.
 - 8. Provide all electrical work associated with the BMS.
 - 9. Provide all wiring in accordance with the latest editions of the local electrical code and the NEC.
 - 10. Divisions 26 to provide dedicated circuits as required, refer to Division 26 drawings for junction box locations. Controls contractor to provide transformers and field terminations.
 - 11. Incorporate surge transient protection into the design of the system to protect the electrical components in all DDC controllers, TECs, panels and workstations.
 - 12. Provide control power transformers for valve actuators, damper actuators and all instruments and devices provided under this contract for low voltage operation.
 - 13. Provide all wells for water monitoring devices, temperature sensors, flow switches and alarms, as required.
 - 14. Furnish control dampers actuators not integral to damper factory assemblies. Furnish damper actuators meeting or exceeding the specifications, listed in the associated sections and located as shown on all drawings. Coordination is required with Division 23, regarding the installation, final sizing and method of fixing and delivery of the dampers.

DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

15. Provide system graphics for each system. See section herein for requirement.
16. Provide engineering and shop drawings as specified herein.
17. Provide field supervision of the associated elements of work as specified herein.
18. Provide mechanical installation of all control instrumentation etc. as specified herein.
19. Provide testing, calibration and commissioning as specified herein.
20. Provide demonstration of operation and system performance testing as specified herein.
21. Provide as-built drawings as specified herein.
22. Provide Operation and Maintenance manuals as specified herein.
23. Provide Personnel Training as specified herein.
24. Provide attendance and support during the commissioning of the project to Divisions 23 and 26, as required by the coordinated commissioning program.
25. With commencement of the project provide test procedure documents (TPD) describing the testing of all interfaces between the BMS and other systems for approval by the Owner, the Engineer and the Management Contractor.

1.5 DEFINITIONS

A. Explanations of terms utilized in this Specification:

1. Provide: Furnish and install, complete, the specified material, equipment or other item and perform all required labor to make a finished and acceptable installation.
2. Furnish: Purchase, store and deliver the specified material, equipment or other item to the project site complete with all necessary appurtenances, supports, etc.
3. Install: Unload at the delivery point at the site and perform every operation necessary to establish secure mounting and correct operation at the proper location in the project.
4. By others: By persons or parties responsible for work at the project other than the party or parties who have been awarded the contract for the work of this trade. In the event that this document is used to acquire work as part of a general construction contract, the words "by others" or "by other trades" shall mean by persons or parties who are not anticipated to be the Contractor for this trade working together with the Construction Manager (CM). In this context, the words "by others" or "by other trades" shall not be interpreted to mean not included in the overall contract.
5. Ductwork: Ductwork, volume dampers, motorized dampers, fire and smoke dampers, diffusers, registers, supports and all other items required for a complete functional system.
6. Piping: Piping, valves, strainers, supports and all other items required for the circulation of water to and from HVAC equipment.
7. Concealed: Embedded in masonry or other construction, installed behind wall furring, within double partitions, above inaccessible ceilings, in crawl spaces, in shafts, etc.
8. Exposed: Not concealed.

1.6 RELATED WORK

- A. Related Documents and Sections: Examine Contract Documents for requirements that directly affect or are affected by Work of this Section. A list of those Documents and Sections include, but is not limited to the following:
 - 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions, and Division 01 General Requirements Specification Sections, apply to this Section.
 - 2. Other Related Sections:
 - a. All Division 21 Equipment Sections
 - b. All Division 22 Equipment Sections
 - c. All Division 23 Equipment Sections
 - d. All Division 26 Equipment Sections
 - e. All Division 28 Equipment Sections

1.7 COORDINATION

- A. Coordinate work under provisions of Division 1 as applicable.
- B. Ensure installation of components is complementary to installation of similar components in other systems.
- C. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.
- D. Contractor to coordinate all BMS integrations, inputs and outputs to systems and equipment with final approved submittals. Integration to devices, controllers and systems requiring special programming, hardware, network switches, gateways and wiring to perform interface or integration shall be provided by the controls contractor. All IP based equipment, including network switches, shall be submitted for review and coordinated with owner's IT for approval.
- E. Ensure system is completed and commissioned.
- F. Division 23 - BMS Contractor shall be responsible for all electrical work associated with the BMS control system as detailed below.
 - 1. Perform all wiring in accordance with all local and national codes. Refer to Division 26, Electrical Specifications for areas requiring more stringent installation procedures.
 - 2. Provide 120-volt branch circuits from junction boxes to DDC panels.
 - 3. Provide 120VAC for all instruments, valves, dampers, and control devices requiring 120VAC supply. All work shall be installed in accordance with Division 26.
 - 4. Provide 24-volt power, control and network interface wiring from network DDC controllers and panels to all application specific controllers (VAVs, TECs etc.), local display devices through end control devices, complying with requirements of Division 26.
 - 5. BMS shall monitor fire alarm system control relays responsible for equipment shutdowns and stop normal operations in order to prevent the potential of

- nuisance alarms during fire related events. Provide BMS internal logic to parallel to fire alarm system smoke shutdown for variable frequency drive and motor starters related to emergencies as well as fire alarm system duct mounted smoke detectors according to local code requirements.
6. Provide transformers, where required, to match control voltage with actuator or sensor voltage.
- G. The Division 23, Mechanical Contractor shall provide the following:
1. All openings and pressure taps for water monitoring devices, flow switches, control valves and wells furnished by the BMS Contractor.
 2. Installation of all dampers and measuring devices. All control dampers shall be furnished by BMS Contractor where not specified as an integral component of a packaged unit.
 3. Furnish and install all access doors.
 4. Items furnished by BMS Contractor but installed by Sections of Division 23, Mechanical Contractor:
 - a. Flow elements directly installed in the piping or ductwork, such as airflow measuring inlet probes, magmeters, pressure switches and thermowells.
 - b. Automatic control valves.
 - c. Control dampers.
- H. The Division 26, Electrical Contractor shall provide the following.
1. Wiring of power feeds through all disconnects, starters, and to electric motors.
 2. Division 26 contractor to provide all line voltage 120 VAC power wiring from electrical panels to junction boxes for the purpose of powering control panels. Junction boxes to be provided by Division 26 and shall be wired in conduit from dedicated circuits. Division 26 shall provide circuit breakers at all electrical panels for use by the BMS contractor.
 3. Motor starters and motor feeder
 4. If upon Div. 23 contractor's final sizing of control devices it has been determined that the power required for the assembly exceeds the power available from the BMS control panel, the Div.23 contractor shall coordinate with the Div. 26 contractor for additional power.
- I. The Division 28, Fire Alarm System Contractor shall provide the following.
1. Wiring of power feeds through all smoke detectors.
 2. Smoke detectors shall be furnished by Division 28 and installed by Division 23.
 3. All necessary monitored relays and outputs to BMS for the purposes of alarming and smoke control functions and pressurization as required by BMS and described herein and on contract drawings.

1.8 REFERENCE STANDARDS

- A. All work shall conform to the following Codes and Standards, where applicable:
1. National Fire Protection Association (NFPA) Standards, as specified.
 2. National Electrical Code (NEC) and applicable local Electrical Code.
 3. Underwriters' Laboratories (UL) listing and labels, as specified.
 4. Factory Mutual (FM).

5. American National Standards Institute (ANSI).
6. National Electric Manufacturers' Association (NEMA).
7. American Society of Mechanical Engineers (ASME).
8. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
9. Air Movement and Control Association (AMCA).
10. Institute of Electrical and Electronic Engineers (IEEE).
11. American Standard Code for Information Interchange (ASCII).
12. Manufacturer's Standardization Society of the Valve and Fitting Industry (MSS).
13. Electronics Industries Association (EIA).
14. Occupational Safety and Health Administration (OSHA).
15. American Society for Testing and Materials (ASTM).
16. NFPA 92A and 92B
17. NFPA 101, 2002

1.9 GENERAL PRODUCT DESCRIPTION:

- A. The building management system provided and installed shall be a distributed logic control system complete with all software and hardware functions.
 1. The controllers shall be direct digital control (DDC) type and based on ANSI/ASHRAE Standard 135, BACnet controlling all mechanical equipment using BTL (BACNET Testing Labs) Certified native BACnet-compliant components.
- B. The building management system shall consist of the following:
 1. BMS Server
 2. Stand-alone DDC Controllers (32 bit processors) provided for each piece of main equipment. The intent of this specification is that the loss of any one DDC controller shall not affect the operation of more than one piece of main equipment while minimizing the impact on other equipment and HVAC systems. It shall only affect the points connected to the failed DDC controller. It is not acceptable that any control loops are split across two or more DDC control panels.
 3. Stand-alone Terminal Equipment Controllers (TECs), otherwise referred to as Application-Specific Controllers (ASCs), shall only be used for terminal equipment.
 4. One (1) Operator workstation comprises of a laptop serving as the operator's terminal to be connected and communicating simultaneously with the entire BMS. The operator terminal shall be able to monitor, adjust, trend, edit, modify, add, delete, backup the entire BMS system (including Terminal Equipment Controllers, DDC controllers, etc.) point database and all programs, provided the operator has the appropriate password access.
- C. The system shall be modular in nature and permit expansion of both capacity and functionality through the addition of sensors, actuators, DDC Controllers, and operator devices.
- D. Controllers shall assign password access and control priorities to either fully assignable point groups or each point individually. The logon password (at PC workstation) shall enable the operator to monitor, adjust and/or control only the

points that the operator is authorized for. All other points shall not be displayed at the PC workstation. (E.g. all base points shall be accessible to any base building operators, but only electrical points shall be accessible to house electricians). Passwords and priority levels for every point shall be fully programmable and adjustable.

- E. The BMS system shall operate with an input voltage rated at 120 Volts, 1 phase, 60 Hertz. All units shall be grounded in accordance with the local Electrical Code and the NEC. All units shall be supplied with filtered power, if required, to preclude noise generation. Signal range shall be 4-20 mA or 0-10 VDC.
- F. The BMS shall be programmed to automatically detect critical alarms that require notification, create an action statement for each alarm, and select the person to receive the notification via e-mail or SMS text message. Software shall transmit email via Owner's existing SMTP server. SMS messages shall operate with any mobile phone carrier.
- G. The control system shall be a high speed, peer to peer BACnet network of DDC controllers and a web based operator interface. All schedules, setpoints, trends, and alarms shall be BACnet objects.
- H. Workstation information access shall be BACnet protocol. Communications shall use ISO 8802-3 (Ethernet) Data Link/ Physical layer protocol.

1.10 SUBMITTALS

A. Submissions Requirements:

1. Clearly identify each submittal requirement indicated and in which submission the information will be provided.
2. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.
3. The following table defines the required submittals and hierarchy for time of submission:

<u>Action Submittals</u>		
Submittal #	Submittal Name	Pre-requisite for Review
1	Submittal Schedule	None
2	Qualification Data	None
3	Specification Compliance Submittal	1
4	Product Data for DDC system	3
5	Individual sensor/device product data	3
6	BTL listing submittal	3
7	Software submittal	3
8	Valve, Damper, and Actuator Delegated Design	3
9	Shop Drawings	3
10	Interface Control Documents	4

11	System Description	4,5 and 10
12	Sample Package (graphics and visible sensors)	4 and 9
13	Closeout Submittal Package	10, 11, and 12

4. Multiple and large Submissions:
 - a. 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.
 - b. In instances when large or multiple submittals are provided with a single submission, the time period for review will be extended and the release of submittals will be coordinated based on contractors' priority for release of equipment. Allow 3 weeks for large submittals.
 5. Submit under provisions of Section 01 3300 – SUBMITTAL PROCEDURES and Division 01 as applicable. Shop drawings to be provided in PDF Format.
 6. All submittals to be digital and searchable. Scanned submittals are not acceptable.
 7. General Contractor comments must be actioned on submittal before submitting to the engineer for review.
 8. Submit shop drawings for each system automatically controlled and integrated. The submittals shall be provided with a comprehensive index and each page of the submittal shall be provided with a page number, drawings shall have a drawing / sheet number, date and revision. Revisions of submittals if required shall provide necessary revision clouding of affected areas on all drawings resubmitted. Drawing submittals shall comprise, at a minimum the following information:
 9. Prepare Drawings using computer software, and provide digital copies to owner.
 10. Scanned drawings are not acceptable.
 11. Title page with submittal title, job name and address, date, contract drawing and specification information (i.e. latest bulletin number and date), and BMS contractor project manager name and phone number, at a minimum.
 12. Include a drawing index sheet listing each drawing number and title that matches information in each title block. Include plans, elevations, sections, and mounting details where applicable.
 13. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 14. Detail means of vibration isolation and show attachments to rotating equipment.
- B. Compliance Review
1. Contractors will provide a Compliance Review of the Specifications, Drawings and Addenda (if any). The Compliance Review is a paragraph-by-paragraph (Drawing by Drawing) review of the Specifications and Drawings with the following information, "C", "D" or "E" marked in the margin of the original Specifications and any subsequent Addenda. Narrative text shall accompany the Drawing Compliance Review.
 - a. "C": Comply with no exceptions.

- b. "D": Comply with deviations. For each and every deviation, provide a numbered footnote with reasons for the proposed deviation and how the intent of the Specification can be satisfied.
- c. "E": Exception, do not comply. For each and every exception, provide a numbered footnote with reasons and possible alternatives.
- d. Note: Unless a deviation or exception is specifically noted in the Compliance Review, it is assumed that the Bidder is in complete compliance with the plans and Specifications. Deviations or exceptions taken in cover letters, subsidiary documents, by omission or by contradiction do not release the contractor from being in complete compliance, unless the exception or deviation has been specifically noted in the Compliance Review. The Bidder may submit the latest state-of-the-art components in lieu of specified items. The engineer and Owner will review deviations from the Specifications.

C. 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 outpoints.
 - 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.
- 4. Complete bibliography of documentation and media to be delivered to Owner.
- 5. Description of testing plans and procedures.
- 6. Description of Owner training.

D. Plan Drawings

- 1. Screened backgrounds of walls, structural grid lines, HVAC equipment, ductwork and piping.
- 2. Room names and numbers with coordinated placement to avoid interference with control products indicated.
- 3. Each desktop operator workstation, server, gateway, network switches, router, DDC controller, control panel instrument connecting to DDC controller, and damper and valve connecting to DDC controller, if included in Project.
- 4. Exact placement of products in rooms, ducts, and piping to reflect proposed installed condition.
- 5. Network communication cable and raceway routing.
- 6. Information, drawn to scale.

7. Proposed routing of wiring, cabling, conduit, and tubing, coordinated with building services for review before installation.
- E. Schematic drawings
1. 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.
 2. I/O listed in table format showing point name, type of device, manufacturer, model number, point address, and cross-reference to product data sheet number. Table to clearly differentiate between analog and digital, input and output points as well as all serial integration (soft points). An allowance for future point integration shall be made to ensure any points found to be necessary during commissioning and start-up can be added.
 3. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
 4. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
 5. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers. Indicate all required electrical wiring of connected data points, including connected control unit and input device, field control panel layout and locations, and parts list coordinated with power panel locations. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
 6. A contractors written sequence of operation for all systems, with specific IO reference by name and number.
- F. Control Panel Drawings
1. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
 2. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
 3. Unique drawing for each panel.
- G. System Network Riser Diagram
1. Each device connected to network with unique identification for each.
 2. Interconnection of each different network in DDC system.
 3. 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.
 4. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.
- H. Power Riser Diagram:
1. Each point of connection to field power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
 2. 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.

3. Each product requiring power with requirements (volts/phase/ hertz / amperes/ connection type) listed for each.
 4. Power wiring type and size, race type, and size for each.
 5. Descriptive data and sequence of operation of operating, user, and application software.
- I. Valve and Actuator Schedule
1. Valve Schedule and design calculations for control valves, and actuators.
 - a. Valve Tag.
 - b. Valve Service.
 - c. Line Size.
 - d. Valve Type.
 - e. Valve Size.
 - f. Pipe connection style.
 - g. Flow (with Units) at Project design and minimum flow conditions.
 - h. Pressure-differential drop across valve at Project design flow condition.
 - i. Valve authority at design conditions.
 - j. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.
 - k. Design and minimum control valve coefficient with corresponding valve position.
 - l. Coil Pressure Drop (approved equipment)
 - m. Design Pressure
 - n. Maximum close-off pressure.
 - o. Leakage flow at maximum system pressure differential.
 - p. Torque required at worst case condition for sizing actuator.
 - q. Valve model and manufacturer.
 - r. Actuator operating voltage.
 - s. Actuator position feedback or end switches.
 - t. Actuator selection indicating torque provided.
 - u. Actuator signal to control damper (on, close or modulate).
 - v. Actuator position on loss of power.
 - w. Actuator position on loss of control signal.
 - x. Actuator model and manufacturer
- J. Damper and actuator schedule
1. Schedule and design calculations for control dampers, and actuators.
 - a. Flow at Project design and minimum flow conditions.
 - b. Pressure-differential drop across damper at Project design flow condition.
 - c. Maximum close-off pressure.
 - d. Leakage flow at maximum system pressure differential.
 - e. Torque required at worst case condition for sizing actuator.
 - f. Actuator operating voltage.
 - g. Actuator selection indicating torque provided.
 - h. Actuator signal to control damper (on, close or modulate).
 - i. Actuator position feedback or end switches.
 - j. Actuator position on loss of power.
 - k. Actuator position on loss of control signal.
 - l. Actuator model and manufacturer

K. Interface Control Documents

1. For each subsystem being integrated into the BAS system (VFDs, lighting controls, chillers, etc.) the contractor shall submit a complete interface control document, coordinated with the approved 3rd party submittals, detailing at a minimum:
 - a. Communication type
 - b. Connection point
 - c. All input and output capability between the two systems
 - d. Connection coordination with 3rd party

L. Product Data

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. Documentation on submitted BMS controllers that have been tested and listed by the BTL or a letter from manufacturer's indicating the anticipated date by which testing is expected to be complete. If for any reason, BTL testing and listing has not been completed, a written commitment shall be provided to upgrade installed controls to a version that meets BTL testing and listing requirements should deficiencies be found during BTL testing.
5. Installation, operation and maintenance instructions including factors effecting performance.
6. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product. A complete index shall be provided with page numbering included on each product sheet.
 - a. Servers.
 - b. Workstations.
 - c. Gateways.
 - d. Network Switches and Routers.
 - e. Protocol analyzers.
 - f. BMS controllers.
 - g. Enclosures.
 - h. Electrical power devices.
 - i. UPS units.
 - j. Accessories.
 - k. Instruments.
 - l. Control dampers and actuators.
 - m. Control valves and actuators.
7. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
8. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

M. Software Submittal

1. As part of the submittal package, the contractor shall include a complete copy of specifications, with confirmation of conformance to all specifications. In the case of non-conformance, the contractor shall specifically highlight the specification section of non-conformance.
2. Cross-referenced listing of software to be loaded on each operator workstation, server, gateway, network switches and DDC controller.
3. Description and technical data of all software provided and cross-referenced to products in which software will be installed.
4. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
5. Description of operator interface to alphanumeric and graphic programming.
6. Description of each network communication protocol.
7. Description of system database, including all data included in database, database capacity and limitations to expand database.
8. 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.

N. Samples:

1. For each of the following exposed product, installed in finished space for approval of selection of aesthetic characteristics including all proposed space temperature, humidity, CO2, pressure, and occupancy sensors for review and written approval by owner's representative.
2. Provide sample of label to be provided for each control device with setting or adjustable range of control for written approval by Owner's Representative.
3. Provide sample(s) of proposed graphic for review and written approval by Owner's Representatives. Graphic samples must be included as part of the original shop drawing submittal package for owner and engineer to review.

O. Color graphics

1. Itemized list of color graphic displays to be provided.
2. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.
3. Intended operator access between related hierarchical display screens.
4. Graphical interface capability
5. System graphics and inclusive of a master organizational plan.

1.11 CLOSEOUT SUBMITTALS

A. Factory Testing Results

1. Submit for approval test reports from the factory program testing procedures.

B. Final Graphic Submittal

1. Submit for approval final graphic samples of all system types (AHU's, VAV's, energy management, integrated systems, etc.).

C. Sensor Calibration Report

1. Submit for approval, a detailed report of the sensor calibration process. The report shall consist of both testing procedures and testing results. Any sensor that has been factory calibrated shall have the factory calibration report included in the calibration submittal.

D. DDC System I/O Checkout Report

1. Submit for approval, a detailed report highlighting the process and results as described in section, "DDC SYSTEM I/O CHECKOUT PROCEDURES".

E. As-built documentation

1. Submit for approval, as-built versions of shop drawings and product data in electronic PDF format. The as-built drawings, drawings, sequences, and products shall accurately reflect every change made to the system operation since approval of the shop drawings. Accurately record actual location of control components, including panels, thermostats, and sensors

F. System readiness confirmation

1. Submit for approval written confirmation of system readiness for testing as defined in section "Final Review".

G. Validation test report

1. Submit for approval all procedures and results as described in section "DDC System Validation Tests".

H. Operation and Maintenance Data: For DDC system to include in emergency, operation and maintenance manuals.

1. In addition to items specified in Section 01 7823 "Operation and Maintenance Data," include the following:
 - a. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
 - b. As-built versions of submittal Product Data.
 - c. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
 - d. 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.
 - e. A complete alarm list, with criticality levels, and distribution assignment.
 - 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. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
- i. Submission of actual programming language used for each system type.
- j. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
- k. List of recommended spare parts with part numbers and suppliers.
- l. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
- m. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
- n. Licenses, guarantees, and warranty documents.
- o. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
- p. Owner training materials.

1.12 QUALIFICATIONS / QUALITY ASSURANCE

- A. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the Specification requirements.
- B. Manufacturer's Qualifications: Firms regularly engaged in manufacture of DDC control equipment, of types and sizes required, and whose products have been in satisfactory use in similar service for not less than 10 years. The manufacturer shall be ISO 9000 certified.
- C. Installer's Qualifications: Company specializing in applying the work of this Section with minimum ten years documented experience and approved by manufacturer.
- D. Install system using competent workmen who are fully trained in the installation of temperature control equipment, and are direct employees of the controls installer. Installing wholesalers, franchisers, dealers, distributors are not acceptable. Electrical subcontractors for the installation of distribution wiring and power are acceptable.
- E. Single source responsibility of BMS Contractor to include complete software, graphics installation and proper operation of the control system, debugging, and proper calibration of each component in the entire system. Third party software/programming and graphics package is not acceptable.
- F. BMS Contractor shall have an in-place support facility within 50 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment for a period of not less than 10 years.
- G. Manufacturers shall submit evidence of electric and DDC parts availability through authorized parts wholesaler at time of bid.

H. Commissioning of a system or systems specified in this section is part of the construction process which includes documentation and testing of these systems, as well as training of the Owner's operation and maintenance personnel.

I. Quality Assurance Program

1. The BMS Contractor shall implement a Quality Assurance Program. At minimum, this program shall consist of the following requirements.

- a. The BMS Contractor shall assign a single individual to serve as the Quality Assurance Manager, who is responsible for the management of the program.
- b. The Quality Assurance Manager shall provide or maintain
 - 1) Documentation of training for employees-including office, field, and subcontractors- on the Quality Assurance Program.
 - 2) Written verification that each worker on the project has read the Specification sections outlining the project requirements for his or her area of specialty. The initial project team shall be documented in the first project submittal.
 - 3) A detailed audit trail for all Quality Assurance issues, including: problem ID number, date of original problem report, name of individual initiating report, and individual assigned responsibility for resolving the problem.
- c. Each individual team member shall be responsible for identifying and reporting Quality Assurance problems and for assisting, as requested by the Quality Assurance Manager, in the resolution thereof.

1.13 PRE-INSTALLATION CONFERENCE

- A. Convene a conference one week prior to commencing work of this Section, under provisions of General Conditions and Division 1 as applicable.
- B. Require attendance of parties directly affecting the work of this Section.

1.14 EXTRA MATERIALS

- A. Submit maintenance materials under provisions of General Conditions and Division 1 as applicable.
- B. Provide spare parts list.

1.15 PROTECTION OF SOFTWARE RIGHTS

- A. Prior to delivery of software, the Owner and the party providing the software will enter into a software license agreement with provisions for the following:
 1. Limiting use of software to equipment provided under these specifications.
 2. Limiting copying.
 3. Preserving confidentiality.
 4. Prohibiting transfer to a third party.

5. Provided they are available at a cost satisfactory to the owner warranties of unlimited duration.

1.16 CODES AND APPROVALS

- A. All work, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of the local and state, and federal authorities. Such codes, when more restrictive, shall take precedence over these plans and specifications. As a minimum, the installation shall comply with current editions in effect 90 days prior to receipt of bids of the following codes. All products of the DDC system shall be provided with the following agency approvals. With the submittal documents, verification that the approvals exist for all submitted products shall be provided. Systems or products not currently offering the following approvals are not acceptable.
 1. NEMA standards pertaining to components and devices for DDC control systems.
 2. NEMA EMC1 - Energy Management Systems Definitions.
 3. Requirements of NEC pertaining to installation of DDC control systems, including, but not limited to, remote-control, signaling and power-limited circuits.
 4. Provide DDC control system components and ancillary equipment which are UL-listed and labeled.
 5. The BMS system shall be UL916PAZX listed.
 6. Federal Communications Commission (FCC) Rules, pertaining to components and devices for DDC control systems and Section 15 governing radio frequency electromagnetic interference and be so labeled
 7. Electronic Industries Association (EIA) Std RS-232 pertaining to interfacing requirements for connecting data terminals and communication equipment.
 8. IEEE Std 488, "Standard Digital Interface for Programmable Instrumentation", for interfacing instrumentation into system.
 9. ANSI X3.4, "Code for Information Interchange", requirements for interfacing computer data processing with communication terminal equipment.
 10. ASME MC85.1 - Terminology for Automatic Control
- B. The following current NFPA and ASHRAE Standards and Guides are applicable.
 1. NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences
 2. NFPA 90B Warm Air Heating, Air Conditioning
 3. NFPA 92A, Recommended Practice for Smoke-Control Systems
 4. NFPA 92B, Guide for Smoke Management Systems in Malls, Atria, and Large Areas
 5. ASHRAE 85 - Automatic Control Terminology for Heating, Ventilating, Air Conditioning
 6. ASHRAE 135 - Building Automation and Control Networks (BACnet)
- C. All system components are to be designed and built to be fault tolerant.
 1. Provide satisfactory operation without damage at 110% above and 85% below rated voltage and at +3 hertz variation in line frequency.
 2. Provide static, transient, and short circuit protection on all inputs and outputs. Communication lines shall be protected against incorrect wiring, static

transients and induced magnetic interference. Bus connected devices shall be AC. coupled, or equivalent so that any single failure will not disrupt or halt bus communication.

1.17 WARRANTY

- A. The system, including all hardware, software and workmanship, shall be guaranteed for a period of one (1) year from the date of final acceptance. Any manufacturing defects arising during this warranty period shall be corrected at no cost to the Owner. Warranty shall include one complete heating and cooling season.
- B. All applicable software, as detailed in this specification, shall be updated by the BMS contractor free of charge during the warranty period to insure that the system software is the most up-to-date software available, for the system hardware installed, at the end of the warranty.
- C. The system shall be free from defects in installation workmanship for a period of one year from acceptance. The BMS Contractor shall, free of charge, correct any defects in workmanship within one week of notification in writing by the Owner.
- D. All corrective software modifications made during the warranty service period shall be updated on all user documentation and on user and manufacturer archived software disks.

1.18 TRAINING

- A. Provide five (5) full days of training on site.
- B. The BMS Contractor shall provide instructors to give full instructions to designated personnel in the adjustment, operation and maintenance of the system installed. Instructors shall be thoroughly familiar with all the aspects of the subject matter they are to teach. All training shall be held during the normal work hours of 8:00am to 4:30pm weekdays.
- C. Training shall include but not limited to:
 - 1. Explanation of drawings and operations and maintenance manuals.
 - 2. Walk thru of the job to locate control components.
 - 3. DDC Controller and TEC (ASC) operation.
 - 4. Explanation of adjustment, calibration and replacement procedures.
- D. Training of the Owner's operation and maintenance personnel is required in cooperation with the Owner's Representative. Provide competent, factory, authorized personnel to provide instruction to operation and maintenance personnel concerning the location, operation, and troubleshooting of the installed systems. The instruction shall be scheduled in coordination with the Construction Manager after submission and approval of formal training plans.

1.19 TECHNICAL PROPOSALS

- A. Technical proposals shall be prepared in accordance with these specifications. Two (2) copies of the proposal shall be submitted to the owner, general contractor, and consulting engineer at time of bid. Proposals that are unbound, loose, in a file folder, stapled, stapled in a manila file folder, etc., will not be acceptable. The technical proposal shall include the following data/information as a minimum. The order of listing here is not intended to indicate, nor should it be construed to indicate, the relative importance of the data/information:
1. Information on organizational capability to handle this (project management, personnel, manufacturing, single source responsibility, etc). Including contact references.
 2. Information on training program to demonstrate specification compliance.
 3. System Configuration as proposed including technical data to support the information below:
 - a. Describe system architecture including a schematic layout with location and type (model number) of all DDC control panels.
 - b. Describe system operation, functions and control techniques.
 - c. Modularity.
 - d. Provisions against obsolescence due to technological advancement.
 - e. Provide hardware and software data sheets on system interfaces and integration requirements.
 4. Detailed description of all operating, command, application, and energy management control software provided for this project.
 5. A written guarantee of how long the system proposed will be a standard product and backed by ongoing parts availability and factory trained field support.
 6. A signed certificate stating the Contractor has read the performance and functional requirements, understands them and his technical proposal shall comply (line by line conformance) with all parts of the specification. (Concordance Summary-).
 7. Supply with the proposal a recommended spare parts listing, which the Owner should maintain at the site, with the associated costs of each part. Contractor shall provide lists for both warranty period spare parts requirements as well as spare parts needed beyond the warranty period. Spare parts shall be made available for 10 years beyond warranty period.
 8. Proposal will provide a Compliance Review of the Specifications, Drawings and Addenda (if any). The Compliance Review is a paragraph-by-paragraph (Drawing by Drawing) review of the Specifications and Drawings with the following information, "C", "D" or "E" marked in the margin of the original Specifications and any subsequent Addenda. Narrative text shall accompany the Drawing Compliance Review.
 - a. "C": Comply with no exceptions.
 - b. "D": Comply with deviations. For each and every deviation, provide a numbered footnote with reasons for the proposed deviation and how the intent of the Specification can be satisfied.
 - c. "E": Exception, do not comply. For each and every exception, provide a numbered footnote with reasons and possible alternatives.
 - d. Note: Unless a deviation or exception is specifically noted in the Compliance Review, it is assumed that the Bidder is in complete compliance with the plans and Specifications. Deviations or exceptions

taken in cover letters, subsidiary documents, by omission or by contradiction do not release the contractor from being in complete compliance, unless the exception or deviation has been specifically noted in the Compliance Review. The Bidder may submit the latest state-of-the-art components in lieu of specified items. The engineer and Owner will review deviations from the Specifications.

9. Information on the maintenance during warranty period.
10. Information on service contract.

- B. Submit technical proposals with pricing in accordance with the Instructions to Bidders.

PART 2 - PRODUCTS

2.1 ACCEPTABLE BMS MANUFACTURERS / PRODUCT LINE

- A. Alerton - BACtalk

2.2 ACCEPTABLE INSTALLERS/INTEGRATORS

- A. Installers/Integrators: Company specializing in applying the work of this section with minimum 10 years documented experience approved by the manufacturer and determined acceptable following a review of pre bid qualification package.

2.3 ENVIRONMENT

- A. All equipment detailed in this specification or other equipment associated with the BMS shall be capable of operation in the following conditions without detriment to the equipment.
 1. 0-45°C (32°F – 113°F)
 2. 0-95% RH

2.4 NETWORKING COMMUNICATIONS:

- A. The design of the BMS shall network the operator workstations, DDC and TEC Controllers all communicating via BACnet. The network architecture shall consist of two levels, a primary high performance Building Level Network (BLN) for all DDC controllers and operator workstations and a secondary, Floor Level Network (FLN) that connects TECs for terminal units.
- B. Access to system data shall not be restricted by the hardware configuration of the building management system. The hardware configuration of the BMS network shall be totally transparent to the user when accessing data or developing control programs.

C. Building Level Network

1. The operator workstation and DDC Controllers shall communicate on the BLN such that communications may be executed directly between DDC Controllers, directly between workstations and between DDC Controllers and workstations via a BACnet LAN.
2. All operator devices shall have access to all point status and application report data or execute control functions for any and all other devices via the BLN or FLN. Access to data shall be based upon logical identification of building equipment. No hardware or software limits shall be imposed on the number of devices with global access to the network data.
3. BLN shall provide the following minimum performance:
 - a. Provide high-speed data transfer rates for alarm reporting, report generation and upload/download network devices. System performance shall insure that an alarm occurring at any DDC Controller is displayed at the PC workstation or other DDC controllers or alarm printers within 5 seconds.
 - b. Support of any combination of DDC Controllers and operator workstations directly connected to the BLN. A minimum of 30 devices shall be supported on a single BLN.
 - c. Message and alarm buffering to prevent information from being lost.
 - d. Error detection, correction and re-transmission to guarantee data integrity.
 - e. Synchronization of real-time clocks between DDC Controllers, including automatic daylight savings time corrections.
 - f. All network wiring between DDC Controllers and DDC Controllers and operator workstations shall be in conduit (as a minimum).
 - g. The BLN shall allow the DDC Controllers to access any data from, or send control commands and alarm reports directly to, any other DDC Controller or combination of controllers on the network without dependence upon a central or intermediate processing device. DDC Controllers shall send alarm reports to multiple operator workstations without dependence upon a control or intermediate processing device. The peer-to-peer network shall also allow any DDC controller to access, edit, modify, add, delete, back up, restore all system point database and all programs.
 - h. The BLN shall allow the operators to assign password access and control priorities to each point individually. The logon password (at any PC workstation) shall enable the operator to monitor, adjust and control only the points that the operator is authorized for. All other points shall not be displayed at the PC workstation. (e.g. all base building points shall be accessible to any base building operators, but only electrical points shall be accessible to house electricians). Passwords and priorities for every point shall be fully programmable and adjustable.

D. Floor Level Network

1. This level communication shall support a family of Terminal Equipment Controllers and shall communicate bi-directionally with the BLN through DDC Controllers for transmission of global data via a BACnet LAN.
2. Terminal Equipment Controllers shall be arranged on the FLN in a functional relationship manner with DDC Controllers.

E. Web Browser Interface

1. The web browser shall provide a comprehensive user interface. Using a collection of web pages, it shall be constructed to "feel" like a single application and provide a complete and intuitive mouse/menu driven operator interface. It shall be possible to navigate through the system using a web browser. The web browser shall provide for Navigation and Action for display of animated colorgraphics, schedules, alarms/events, live graphic program, active graphic setpoint controls, configuration menus for operator access, reports, trends, reporting actions for events.
2. On launching the web browser and selection of appropriate domain name of IP address, the operator shall be presented with a login page that will require a login name and password. Navigation of the system shall dependent on the operator's security access privileges.
3. Provide remote alarm notification utilizing e-mail and SMS text messages.

2.5 DDC CONTROLLER

- A. Controllers shall be complete with uninterruptible power supplies (1/2 hour rated), a real time clock, input and output modules, memory, processors and all other items necessary for proper and correct interfacing and operation of the control functions described in this Specification.
- B. All controllers shall have peer-to-peer communications. All controllers shall have a standalone capability such that a failure of the operator's station shall still permit the plant and controls associated with the controllers, to continue to operate normally with the controllers continuing to communicate with one another.
- C. In the event of transmission failure in the controller network the controllers shall continue to operate with all sequence interlocks and control strategies operating normally except those that require global information. Either user adjustable default values or the last sensed value (user selectable) shall then be assumed for these global parameters.
- D. Controllers shall be able to provide the operator's station with status information concerning their internal operations. This information shall include, but not be limited to:
 1. Data transmission and verification.
 2. Input/output point status (i.e. sensor fault, point forced, etc).
 3. Program status (i.e. program error, program running, etc).
 4. Internal battery condition.
- E. All necessary interfacing equipment shall be provided so that the controllers are fully compatible with all items of plant and equipment.
- F. The controller shall be capable of accepting binary, analog, pulsed inputs and providing binary and analog outputs as necessary to meet application requirements.
 1. Binary input - Shall monitor the change of state of a dry contact.

2. Pulsed input - Pulses (dry contact closures i.e. binary type input) originating typically from flow meters, electrical kWh or kVA meters, etc. and shall be accumulated into registers. A register shall be resettable to zero either by software or operator command. The input must be able to accept pulses up to a frequency of 10Hz with a minimum duration of 50ms. All counts must be stored in a non-volatile register so the count value is not affected by a power failure.
 3. Binary output - A dry contact. Contact ratings shall be coordinated with the equipment being controlled.
 4. Analog inputs - Analog to digital conversion (ADC) with a minimum resolution of 1024 counts (10 Bit) over the input range (i.e. 0-10V, 2-10V, 0-20mA, 4-20mA etc.) of the sensor. The sensor range shall match the process control range. Any equipment necessary for the conversion of an input signal to the required input level shall be provided.
 5. Analog outputs - Digital to analog conversion (DAC) shall be performed by the controllers with a minimum resolution of 256 counts (8 Bit) over the output range which shall also match the control range of the device and/or system being controlled. Any equipment necessary for the conversion of the output signal to the required process level (i.e. 0-10V, 2-10V, 0-20mA, 4-20mA etc.) shall be provided. Where analog outputs are specified driving damper and valve actuators, they shall not be used to drive raise/lower actuators through interface devices.
 6. Universal inputs-Shall be configurable to either binary or analogue input and shall have the features defined above.
- G. Hardware Override Switches: The operator shall have the ability to manually override automatic or centrally executed commands at the DDC panel via local, point discrete, on-board hand/off/auto switches for binary control points and gradual switches for analog control type points. These override switches shall be operable whether the panel is powered or not. In lieu of onboard switches, switches may be flush mounted on a panel adjacent to the DDC panel.
- H. Each controller or controller location shall be provided with spare hardware capacity for future additions of at least 15 percent of each type of point and 25% spare memory capacity for future connection. Universal inputs may be counted as either a spare digital or analog point, but not both. Note that this spare capacity may be accomplished by the addition of input/output modules. Memory shall also be sufficient to allow all programs associated with these points to be run in the controller. The Contractor shall state in his offer how many spare points are actually available on each controller or at each controller location and the expansion capability.
- I. The controllers shall be provided with their own internal battery backup power supply, capable of maintaining all memory including the real time clock for not less than 72 hours. The battery shall be easily replaceable i.e. not soldered to the PCB. A capacitor-based alternate to maintaining memory and real time clock for not less than 72 hours shall also be acceptable.
- J. Each analog input shall be calibrated (to compensate for non-linear characteristics of input devices, line resistance and similar items) to achieve an accuracy, of the displayed value on the operator's station, as detailed in this specification for each

sensing device. Calibration and scaling data shall be retained in the controller memory. Open or closed circuits on sensor inputs shall be recognized by the controller and annunciated as alarms on the system operator's station(s).

- K. It shall be possible to characteristics each analog output to an actuator in order to obtain a near-linear response from the device the actuator is controlling. This may take the form of a look up table with a minimum of 6 coordinates, such that the linear output from a control loop is converted into a non-linear control signal to the actuator.
- L. The controllers shall be mounted in control panels, which shall meet the following environmental requirements:
 - 1. Control panels located in heated areas shall be NEMA Type 1.
 - 2. Control panels located in unheated areas or in areas subject to dust or oil shall be NEMA Type 12.
 - 3. Control panels located in exterior areas or in areas subject to rain, dripping liquid, or hosing, including kitchen areas shall be NEMA Type 4X, stainless steel.
 - 4. All installations shall provide necessary heating or cooling to support installed equipment based on local environmental conditions.
- M. The controllers shall be constructed so that the control panels and internal terminal strips can be mounted, and electrical terminations made, with all electronics being added at a later date during the testing and commissioning.
- N. DDC controllers shall be used for main HVAC equipment controls.
- O. Power fail restart: In the event of a loss of normal power there shall be an orderly shutdown of all standalone DDC panels to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for critical control configuration data, including storage of controller firmware, controller application program, schedules, and the values of any setpoints, variables, constants, or other parameters which will not automatically be refreshed by the workstation or a peer device within 60 seconds of restoration of power. Battery back-up shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours. Upon restoration of normal power, the DDC panel shall automatically resume full operation without manual operation.

2.6 DDC CONTROLLER RESIDENT SOFTWARE FEATURES

- A. All software relating to plant control and monitoring detailed in this Specification shall reside at controller or unitary controller level. Only management software shall reside at the operator station.
- B. All programs shall be scanned every two seconds as a minimum.
- C. Software shall include diagnostic routines that check hardware for correct operation. All hardware faults shall be annunciated on the operator's station(s).
- D. For further details see Device Schedule in this Specification.

2.7 TERMINAL EQUIPMENT CONTROLLERS (TEC)

- A. Where a controller is used to monitor and control exhaust fans, FCUs, etc, they shall be classed as terminal equipment controllers (TECs).
- B. TECs shall be either small freely programmable controllers or firmware application specific controllers, which shall be selected to meet the performance requirements of the Specification.
- C. Each TEC shall meet the specified requirements of a controller except where specified to the contrary.
- D. Each TEC shall have its application program, setpoints, limits and schedules etc., backed up on non-volatile memory or maintained via batter for a minimum of 2 years.
- E. Real time clock functions are not essential where these commands are generated by other controllers, which shall also control the transfer of information to, from and between TECs on the same communications network.
- F. Each TEC shall be interrogated and adjusted by an operator's station that may plug into the network at any point.
- G. Only input and output points necessary to meet the functional requirements of this specification are required to be supplied. The spare capacity requirement, as detailed in the section covering DDC Controllers, is not required.

2.8 Workstation / Laptop Computer

- A. Provide a laptop computer and a full featured keyboard.
- B. The laptop operator's terminal shall communicate to the Ethernet network or plug directly into individual DDC panels. Provide a user-friendly English language-prompted interface for quick access to system information.
 - 1. The Contractor shall supply the Notebook type PC computers, indicated on the Contract Drawings and as specified herein, that shall be capable of accessing all system data.
 - 2. Each laptop shall be purchased within 6 months of substantial completion of the Contract. Each notebook computer shall be Dell Precision 7680 or approved equal, with the following minimum requirements:
 - a. CPU: Intel Core i9-13950HX, 24 Core / 32 Thread, 5.50 GHz, 36MB cache.
 - b. Memory (RAM): 32GB 5600MT/s CAlM, non-ECC
 - c. Graphics Card: NVIDIA RTX 2000 Ada, 8 GB GDDR6
 - d. Hard Drive: 1TB Solid State Drive
 - e. Wireless network card, Wi-Fi 6 compatible.
 - f. Display: 16-inch display, FHD+, minimum 1920x1200 resolution.
 - g. Integral touchpad, speakers, and webcam.
 - h. External optical wireless mouse.
 - i. Each notebook computer shall be supplied with a padded carrying case.
 - 3. Each notebook computer shall be equipped with the most recent issue of the following software:

- a. Microsoft Windows 11 operating system, latest version with latest service pack version.
 - b. Microsoft Office, latest version.
 - c. McAfee Antivirus, latest version
 - d. DVD+RW and CD-RW "Roxio" editing software, latest version, and 10 blank DVD+RW DVDs.
 - e. All software necessary for viewing CD-ROM O&M Manual.
 - f. All utilities necessary for management of the network of controllers and devices.
 - g. All BMS software and licenses necessary to perform all the all the monitoring, command and diagnostic functions required by a system operator or a service technician. Usage shall be controlled by License Keys installed on the notebook computer.
4. Laptop is to be used for System Monitoring and System Maintenance shall be equipped with the latest version of the following software:
 - a. All BMS software necessary to perform all the monitoring functions specified herein.
 - b. All BMS software necessary to perform all the monitoring, command and data management functions required by the OWS.
 - c. All utilities necessary for management of the network of controllers and devices.

2.9 Building Management System Server - Rack Mounted:

- A. BMS server shall be provided for information management, network alarm management and database management functions. All real-time control functions shall be resident in the DDC Controllers to facilitate greater fault tolerance and reliability.
- B. Contractor shall provide a wall mounted or free standing rack for mounting server and install server according to server manufacturer's recommendations.
- C. The Contractor shall supply the Server indicated on the Contract Drawings or specified herein. The Server shall be an IBM compatible, blade type computer no larger than 2U.
- D. Each Server shall have Server a hard drive capacity sufficient to store all data collected by the system for one calendar year, and device for transferring data and programs onto an external hard drive or USB memory key.
- E. Each Server shall be purchased within 6 months of substantial completion of the Contract. Each Server shall be Dell Precision Rack 7910 Workstation Series or approved equal, with the following minimum requirements (hardware shall be the latest version available at time of purchase):
 1. Processor: Intel Xeon Gold 5218, 16 Core / 32 Thread, 2.30 GHz, 22MB Cache.
 2. Memory (RAM): 32GB, DDR4-2666MHz.
 3. Solid State Drive (Boot): 512GB Solid-State Drive.
 4. Hard Drive (Storage): 10TB 7200 RPM SATA Hard Drive 6.0 Gb/s
 5. Integrated Network Adapter: 10/100/1000 Ethernet.

6. Power Supply: 550W (minimum), 80 Plus Platinum.
 7. Operating System-Windows Server, 64Bit, English, or as required by BMS software packages.
 8. Rack-mounted console with 19" LCD display, full 88-key keyboard and touch. Console shall be within 1U rack-mountable housing.
 9. All necessary serial, parallel, and network communication ports and all cables for proper system operation.
 10. Contractor shall supply two (2) 64 GB (minimum) USB 3.0 Flash Drives.
- F. Each Server is to be used for System Monitoring and System Maintenance shall be equipped with the latest version of the following software:
1. All BMS software necessary to perform all the monitoring functions specified herein.
 2. All BMS software necessary to perform all the monitoring, command and data management functions required by the Server.
 3. All utilities necessary for management of the network of controllers and devices.

2.10 CONTROL WIRE AND CABLE

- A. Wire: Single conductor control wiring above 24 V.
1. Wire size shall be at least 14 AWG and meet all electrical local code requirements and in accordance with Div 26 requirements. AWG.
 2. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch lay.
 3. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.
 4. Conductor colors shall be black (hot), white (neutral), and green (ground).
 5. Furnish wire on spools.
- B. Single Twisted Shielded Instrumentation Cable 24 V and Less:
1. Wire size shall be a minimum No. 18 AWG.
 2. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
 3. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
 4. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
 5. Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be Type PLTC cable.
 6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
 7. Furnish wire on spools.
- C. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.
1. Cable shall be plenum rated.
 2. Cable shall comply with NFPA 70.

3. Cable shall have a unique color that is different from other cables used on Project.
4. Copper Cable for Ethernet Network:
 - a. 100BASE-TX.
 - b. TIA/EIA 586, Category 5e or Category 6.
 - c. Minimum No. 22 AWG solid.
 - d. Shielded Twisted Pair (STP) or Unshielded Twisted Pair (UTP).
 - e. Thermoplastic insulated conductors, enclosed in a thermoplastic outer jacket, Class CMP as plenum rated.

D. UNINTERRUPTABLE POWER SUPPLY

1. The following equipment shall be provided with uninterruptible power supplies:
 - a. BMS Control Panels
 - b. BMS Workstation.
 - c. Servers
 - d. Gateways and network switches
2. Uninterruptible power supply (UPS): provide a self-contained UPS designed for installation and operation sized for at least 125% of the peak demand, and to provide a minimum of 15 minutes of full operation of the controller and input/output expansion modules connected to that controller.
3. Equipment connected to the UPS shall not be affected in any manner by a power outage of a duration less than the rated capacity of the UPS.
4. Each UPS shall be wired such that primary power to the controller will be maintained upon failure of the UPS, including either a relay switch upstream of the UPS or two UPSs in parallel.
5. UPS shall be complete with necessary power supplies, transformers, batteries, and accessories and shall include visual indication of normal power operation, UPS operation, abnormal operation and visual and audible indication of low battery power.
6. UPS shall be provide an alarm contact for monitoring by the BAS of UPS general alarm inclusive On Battery, Low Battery and UPS Shutdown.
7. UPS shall be provided with means for integration for monitoring of general alarm including battery failure.
8. BMS workstation, UPS, and gateways/network switches shall be complete with uninterruptible power supply capable of running all hardware for a period of 1/2 hour.
9. Manufacturer
 - a. Sola SDU Off-Line DIN Rail HeviDuty UPS Series
 - b. Schneider Electric Smart-UPS SUA500PDR
 - c. or equal

2.11 WORKSTATION OPERATOR INTERFACE

A. Basic Interface Description

1. Provide scaled floor plans (Auto Cad or approved equivalent) indicating equipment location, service, and system data as required by the Owner. Graphics to incorporate integrated points communicated via BMS. Origin of

- information shall be transparent to the operator and shall be controlled, displayed, trended, etc. as if the points were hardwired to the BMS.
2. All graphics to include dynamic screen link points for the following as a minimum;
 - a. Manufacturer cut sheets files, either in PDF or other file format for instrumentation and control device represented. All cut sheets to be provided with selection of model provided clearly identified by markings.
 - b. Sequence of operations text file for the systems and devices represented.
 - c. Control system As-Builts
 3. Operator workstation interface software shall minimize operator training through the use of English language prompting, 30 character English language point identification, on line help and industry standard PC application software. The software shall provide, as a minimum, graphical viewing and control of environment, scheduling and override of building operations, collection and analysis of historical data, definition and construction of dynamic color graphic displays, editing, programming, storage and downloading of controller databases, and the ability to export data with Microsoft Word for Windows and Excel for Windows.
 4. Provide a graphical user interface which shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change set points from graphical displays through the use of a mouse or similar pointing device. Provide functionality such that all operations can also be performed using the keyboard as a backup interface device. Provide additional capability that allows at least 10 special function keys to perform often-used operations
 5. The software shall provide a multi-tasking Microsoft Windows environment that allows the user to run several applications simultaneously. Other Windows applications shall run simultaneously with the BMS software including Word, Excel, Access, etc. Provide functionality such that any of the following may be performed simultaneously, and in any combination, via user-sized windows. The operator shall be able to drag and drop information between applications (e.g. click on any point in the alarm screen and drag it into the dynamic trend graph screen to initiate a dynamic trend).
 - a. Dynamic color graphics and graphic control
 - b. Alarm management coordinated with other specification sections
 - c. Week or Month at a Glance with 365 day time-of-day scheduling
 - d. Trend data definition and presentation
 - e. Graphic definition
 - f. Graphic construction
 6. Operator specific password access protection shall allow the user to limit workstation control, display and data base manipulation capabilities for each object in the system. An object shall be defined as any input or output point, set point, system program, etc. The operator privileges shall "follow" the operator to the operator terminal or DDC controller that the operator logs on to. Provide a minimum of 200 passwords.
 7. Operators will be able to perform only those commands on the objects available based on their respective passwords. Menu selections displayed shall be limited to only those items defined for the access level of the password used to log-on.

8. An audit trail report to track system object changes, accounting for operator initiated actions, change made by a particular person or changes made to a specific piece of equipment, designated time frame shall be printed out on command or automatically and archived for future reference. The operator activity tracking data shall be stored in a tamper proof buffer.
9. Software shall allow the operator to perform commands including, but not limited to start up or shutdown of equipment, adjust set points (including multiple TEC subpoints to new settings with one command), add/modify/delete time programming, enable/disable process execution, lock/unlock alarm reporting, enable/disable totalization, enable/disable trending, override PID loop set points, enter temporary override schedules, define holiday schedules, change time/date, automatic daylight savings time adjustments, enter/modify analog warning and alarm limits, View limits, Enable/disable demand limiting for each meter, Enable/disable duty cycle for each load. All values (including setpoints) indicated within specification sequences, including those labelled as adjustable (adj.), shall be modifiable, with the proper password level, from the operator interface or via a function block menu. For these points, it is unacceptable to have to modify programming statements to change the setpoint.
10. Reports shall be generated and directed to either display or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports:
 - a. A general listing of all points in the network
 - b. List of all points currently in alarm.
 - c. List of all points currently in override status.
 - d. List of all disabled points.
 - e. List of all points currently locked out.
 - f. DDC Controller trend overflow warning.
 - g. List all weekly schedules.
 - h. A DDC controller point module status report.
 - i. A change of value cross reference report indicating user defined limit changes.
 - j. Summaries shall be provided for specific points, for a logical point group, for a user-selected group or groups or for the entire facility without restriction due to the hardware configuration of the building management system. Under no conditions shall the operator need to specify the address of the hardware controller to obtain system information.
 - k. Provide a custom reporting package that allows the operator to select, modify, or create custom reports. Each report shall be definable as to data content, format, interval and date. Report data shall be capable of being archived on hard disk for historical reporting. Each physical point or pseudo point shall be assigned an English descriptor for use in reports. The integrated Custom Report Writer capability shall allow the user to format reports of any mix of text, points with status, value and descriptors. The user shall have the capability to modify the defined reports or design unique reports that collect and disperse different combinations of data from the system. A custom report drop down item under the report bar item displays a report dialog box that allows you to schedule, run and view these reports. Spreadsheet packages which require off-line execution or manual translation of data files from one program format to another are not acceptable.

11. User-definable, automatic log-off timers of from 5 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line.

B. Scheduling

1. Provide a graphical spreadsheet-type format for simplification of time-of-day scheduling and overrides of building operations. Provide the following spreadsheet types: weekly, monthly and yearly schedules for a minimum of 365 days in advance.
2. Weekly schedules shall be provided for each building zone or piece of equipment with a specific occupancy schedule. Each schedule shall include columns for each day of the week as well as holiday and special day columns for alternate scheduling on user-defined days. Equipment scheduling shall be accomplished by simply inserting occupancy and vacancy times into appropriate information blocks on the graphic. In addition, temporary overrides and associated times may be inserted into blocks for modified operating schedules. After overrides have been executed, the original schedule will automatically be restored.
3. Zone schedules shall be provided for each building zone as previously described. Each schedule shall include all controllable points residing within the zone. Each point may have a unique schedule of operation relative to the zone's occupancy schedule, allowing for sequential starting and control of equipment within the zone. Scheduling and rescheduling of points may be accomplished easily via the zone schedule graphic.
4. Monthly calendars for a 24-month period shall be provided which allow for simplified scheduling of holidays and special days in advance. Holidays and special days shall be user-selected with the pointing device and shall automatically reschedule equipment operation as previously defined on the weekly schedules.

C. Collection and Analysis of Historical Data

1. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or changes of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting.
2. Trend data report graphics shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or pre-defined groups of at least 10 points. Provide additional functionality to allow any trended data to be transferred easily to an off-the-shelf spreadsheet package such as Microsoft Excel. This shall allow the user to perform custom calculations such as energy usage, equipment efficiency and energy costs and shall allow for generation of these reports on high-quality plots, graphs and charts.
3. Provide additional functionality that allows the user to view trended data on trend graph displays. Displays shall be actual plots of both static and/or real-time dynamic point data. A minimum of 6 points may be viewed simultaneously on a single graph, with color selection and line type for each point being user-definable. Displays shall include an 'X' axis indicating elapsed time and a 'Y' axis indicating a range scale in engineering units for each point. The 'Y' axis shall be manually or automatically scalable at the user's option. Different ranges for each point may be used with minimum and maximum

values listed at the bottom and top of the 'Y' axis. All 'Y' axis data shall be color-coded to match the line color for the corresponding point.

- a. Static graphs shall represent actual point data that has been trended and stored on disk. Exact point values may be viewed on a data window by pointing or scrolling to the place of interest along the graph. Provide capability to print any graph on the system printer for use as a building management and diagnostics tool.
- b. Dynamic graphs shall represent real-time point data. Any point or group of points may be graphed, regardless of whether they have been predefined for trending. The graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the graph and take "snapshots" of screens to be stored on the workstation disk for future recall and analysis. As with static graphs, exact point values may be viewed and the graphs may be printed.

D. Dynamic Color Graphic Displays:

1. Provide graphic floor plan displays and system schematics for each piece of mechanical equipment, including air handling units, supply and exhaust fans and condensate systems to optimize system performance analysis and speed alarm recognition.
2. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands.
3. Dynamic point values (e.g. temperature values, humidity values, flow values and status indication) shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention.
4. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several graphics at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
5. Graphic generation software shall be provided to allow the user to add, modify or delete system graphic displays via an off the shelf graphics package.
 - a. The BMS Contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g., fans, cooling coils, filters, dampers, etc.), complete mechanical systems and electrical symbols.
 - b. Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout or any other logical grouping of points which aids the operator in the analysis of the facility.
 - c. To accomplish this, the user shall be able to build graphic displays that include point data from multiple DDC Controllers including Terminal Equipment Controllers or terminal units.
6. Provide an automatically updated, dynamic display of the site specific BMS architecture indicating the status of all controllers, PC workstations and networks.

7. The graphic development package shall use a mouse or similar pointing device in conjunction with a drawing program to allow the user to perform the following:
 - a. Define symbols.
 - b. Position and size symbols.
 - c. Define background screens.
 - d. Define connecting lines and curves.
 - e. Locate, orient and size descriptive text.
 - f. Define and display colors for all elements.
 - g. Establish correlation between symbols or text and associated system points or other displays.
 8. For each air handling unit provide a tabular graphic summary of that unit and its associated air distribution system. Graphics shall contain, at a minimum, the following information:
 - a. Supply fan's current operating speed and setpoint.
 - b. Manual adjustment of supply fan speed.
 - c. Supply air static pressure and temperature.
 - d. Current damper position or command.
 - e. Current associated space temperature.
 - f. Current preheat, reheat, and cooling valve positions or commands.
 - g. A commandable override point to place all associated terminal units at maximum airflow.
 - h. A commandable override point to place all associated terminal units at minimum airflow.
- E. System Configuration and Definition
1. All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.
 2. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently add, delete or modify any system object including DDC controllers, operator workstations, equipment controllers, reporting definitions, control loops, energy management applications, time and calendar-based programming, totalization, historical data trending, custom control processes, graphic displays, operator passwords, alarm messages, dial up telecommunications definitions, points of any type, etc.
 3. Definition of operator device characteristics for individual points, applications and control sequences shall be performed using instructive prompting software.
 - a. Libraries of standard application modules such as temperature, humidity and static pressure control may be used as "building blocks" in defining or creating new control sequences. In addition, the user shall have the capability to easily create and archive new modules and control sequences as desired via a word processing type format. Provide a library of standard forms to facilitate definition of point characteristics. Forms shall be self-prompting and incorporate a fill-in-the-blank approach for definition of all parameters. The system shall immediately detect an improper entry and automatically display an error message explaining the nature of the mistake.
 - b. Programming shall be performed with the BMS system online, and not interfere with BMS system operation.

- c. Inputs and outputs for any process shall not be restricted to a single DDC Controller, but shall be able to include data from any and all other network panels to allow the development of network-wide control strategies. Processes shall also allow the operator to use the results of one process as the input to any number of other processes (cascading).
- d. Provide the capability to backup and store all system databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation is on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate DDC Controller. Similarly, changes made at the DDC Controllers shall be automatically uploaded to the workstation, ensuring system continuity. The user shall also have the option to selectively download changes as desired.
- e. Provide a program testing utility which allows visual dynamic simulation capability of the symbolically displayed control programs provided. User shall be able to select any portions of inputs, outputs and intermediate program points for visual dynamic display of intermediate values and or results. Provide ports for symbolic engineering tool at each DDC Controller, and (for TECs) at space temperature sensors noted on the plans or as described herein. The symbolic engineering utility shall be self-documenting and shall generate a complete controller program including I/O definition and engineering unit processing requirements, alarm limits, DDC operational program, and English text for all data points. Engineering program documentation shall include computer-driven output of all program data.
- f. Provide context-sensitive help menus to provide instructions appropriate with operations and applications currently being performed.

2.12 ALARM PROCESSING

- A. Alarms shall be classified by their alarm type. The means shall be provided for enabling and disabling each individual alarm on the system. The contractor is responsible for enabling and setting all alarms within the BMS.
- B. Once generated, the alarm shall be processed by its associated Alarm Type and Alarm Level as defined in either the I/O Point Schedules or collaboration with the Owner/Facilities Manager.
- C. The Alarm Types shall be as follows:
 - 1. Mismatch Alarm Type- Mismatch: The alarm is associated with an output command point and its related input giving status feedback of the output command. The alarm is generated when the status feedback does not correspond with the output command status for longer than a defined time delay period, initially set to 1 minute(adjustable).
 - 2. Binary Alarm Type - The alarm is associated directly with an external volt free contact (i.e. a digital input). The alarm may be generated by transitions from either open to closed status, closed to open status, or any change of state. A time delay shall be associated with the alarm such that the alarm does not occur

until the required alarm state has existed for longer than the delay period, initially set to 15 seconds(adjustable).

3. Analog Alarm Type - The alarm is associated directly with an analog input. The alarm is generated by the BMS due to a measured variable exceeding specified limits. It shall be possible to define the limits in two ways:
 - a. Fixed limits. The point has fixed upper and lower alarm limits. If the measured variable rises above the upper limit, or falls below the lower limit, then an alarm is generated. e.g. high alarm limit = 80°F, low alarm limit = 45°F.
 - b. Floating limits. The point has an associated setpoint, and an alarm is generated when the measured variable deviates either above or below the setpoint by more than a given alarm limit value. If the setpoint is changed, the alarm limits are automatically moved to suit, e.g. setpoint = 66°F, alarm limits = Setpoint $\pm$ 2°F.
 4. Hand/Off/Auto (HOA) Type - The alarm is associated with the placement of the HOA switches in the Hand or Off position. HOA switches include but are not limited to controllers and variable frequency drives.
- D. The Alarm Levels shall be as follows:
1. Level 1: Life Safety.
 2. Level 2: Critical Equipment Message.
 3. Level 3: Urgent Message.
 4. Level 4: Normal / Maintenance Message.
- E. Alarm Initiation - Entry delay:
1. All alarms have an adjustable delay time such that the alarm is not triggered unless the alarm condition exists for the delay time. Default entry delays are as follows:
 - a. Level 1 alarms: 1 second
 - b. Level 2 alarms: 10 seconds
 - c. Level 3 alarms: 1 minute
 - d. Level 4 alarms: 5 minutes
- F. Alarm Exit Hysteresis:
1. Each alarm has an adjustable time-based hysteresis to exit the alarm. The default is 5 seconds for all alarms. Once set, the alarm does not return to normal until the alarm conditions have ceased for the duration of the hysteresis.
 2. Each analog alarm additionally has an adjustable percent-of-limit-based hysteresis. The hysteresis requires the alarmed variable to be a percentage above or below (as applicable) the triggering threshold before the alarm is cleared. The default value is 0% for all alarms.
- G. Latching:
1. Any alarm can be configured as latching or non-latching. A latching alarm requires acknowledgement from the operators before it can return to normal, if the exit hysteresis has been met. A non-latching alarm does not require acknowledgement. Default latching status is as follows:
 - a. Level 1 alarms: latching

- b. Level 2 alarms: latching
 - c. Level 3 alarms: non-latching
 - d. Level 4 alarms: non-latching
- H. The operator's station display shall have a dedicated area at the top or bottom of the screen for use as an alarm banner. The alarm banner shall display, as a minimum, the two latest unacknowledged alarms at the top of the current alarm list. Alarms shall be entered into the list according to their type and event order, with the most recent alarm being at the top of the list. As new alarm events occur, the list shall be sorted to keep the list in the desired order.
- I. On occurrence, all alarms shall be put in the alarm list. In addition, the following actions shall be taken dependent upon the alarm type.
- J. Alarm Actions
 - 1. Level 1: Life Safety.
 - a. Initiate remote notification via email/text.
 - b. The alarm printout shall be in bold text or color-coded to clearly differentiate it from Urgent or Normal / Maintenance alarms. It shall be possible to sort or filter the alarm printout by alarm level.
 - c. The banner alarm message display shall be differentiated by means of text size or color from general alarms.
 - d. Shall generate an audible alarm at the operator's station.
 - e. Shall have the ability to bring up an associated alarm graphic or text screen at the operator's station.
 - 2. Level 2: Critical Equipment Message.
 - a. The alarm printout shall be in bold text or color-coded to clearly differentiate it from Urgent or Normal / Maintenance alarms. It shall be possible to sort or filter the alarm printout by alarm level.
 - b. The banner alarm message display shall be differentiated by means of text size or color from general alarms.
 - c. Shall generate an audible alarm at the operator's station.
 - d. Shall have the ability to bring up an associated alarm graphic or text screen at the operator's station.
 - 3. Level 3: Urgent Message.
 - a. Shall generate a banner alarm message.
 - b. Shall generate an audible alarm at the operator's station.
 - c. Shall have the ability to bring up an associated alarm graphic or text screen at the operator's station.
 - 4. Level 4: Normal / Maintenance Message.
 - a. Shall generate a banner alarm message.
 - b. Shall have the ability to bring up an associated alarm graphic or text screen at the operator's station.
- K. It shall be possible, at the highest operator password level, to enable and disable the audible alarm feature of the operator's station for such reasons as maintenance . In addition the keyboard facility to mute the audible alarm shall be provided. Alarms that have been muted shall be re-annunciated if not acknowledged within a user specified time.

1. All alarms associated with a device in maintenance mode, except for level 1 alarms, are suppressed.
 2. If a device is in maintenance mode, a daily level 3 alarm is issued at midnight indicating the devices is still in maintenance mode.
- L. Alarms shall remain active until acknowledged by an operator logged on with the appropriate password level, even if the alarm has physically cleared. Upon acknowledgement, the alarm shall be moved to the appropriate place in the alarm list, the alarm banner shall be updated as necessary. When an alarm is acknowledged, the audible alarm, if enabled, shall be muted unless another unacknowledged critical or general alarm exists on the system.
- M. The system shall be capable of alarm notification escalation during periods in which alarms go unacknowledged for a period of time. The escalation shall provide means to notify assigned individuals and/or groups via all means addressed within this specification. The escalation shall be tiered in a manner so that multiple stages of escalation are programmable. Escalation shall be developed by contractor in collaboration with the Owner/Facilities Manager
- N. Post exit suppression period:
1. To limit alarms, any alarm may have an adjustable suppression period such that, if the alarm is triggered, its post-suppression timer is triggered and the alarm may not trigger again until the post-suppression time has expired. Default post suppression periods are as follows:
 - a. Level 1 alarms: 0 minutes
 - b. Level 2 alarms: 5 minutes
 - c. Level 3 alarms: 24 hours
 - d. Level 4 alarms: 7 days
- O. It shall be possible to acknowledge alarms on both an individual and group basis.
- P. Upon clearance of an alarm, it shall be removed from the alarm list.
- Q. All alarm events shall be included in the historical data program.
1. All alarms in the alarm list.
 2. Level 1: Life Safety alarms only.
 3. Level 2: Critical Equipment Message. alarms only.
 4. Level 3: Urgent Message alarms only.
 5. Level 4: Normal Message alarms only.
 6. Hand/Off/Auto alarms only.
 7. Acknowledged alarms only.
 8. Selection of alarms associated with an individual drive or plant equipment only.

2.13 CONFIGURATION

- A. Configuration data shall be stored in the DDC Controllers or the Terminal Equipment Controllers. Configuration data shall include but not be limited to the following:

1. The point identifier (minimum of 12 characters).
2. The point descriptor (minimum of 32 characters).
3. The engineering unit applicable (°F, psi, gpm etc).
4. The point alarm message if applicable (minimum of 80 characters).
5. Other miscellaneous information necessary for the correct operation of the entire BMS (e.g. trending run hours, accumulation, access levels etc).

2.14 BMS INTEGRATION WITH OTHER SYSTEMS AND DEVICES

A. DX PACKAGED AIR HANDLING UNIT

1. The communication interface shall allow the BMS read capabilities.
2. It shall be the responsibility of the BMS contractor to review requirements and coordinate with the approved submittal from the equipment manufacturer for this integration. This integration shall be done via BACnet IP or BACnet MSTP if BACnet IP is not available.
3. Typical Software Points shall be as follows:

Point	Type	Alarm	Short Term Trend	Long Term Trend	On BMS Graphic
Allow for a minimum of 30 points	TBD	TBD	TBD	TBD	Yes

B. Energy Recovery System

1. The communication interface shall allow the BMS read capabilities.
2. It shall be the responsibility of the BMS contractor to review requirements and coordinate with the approved submittal from the equipment manufacturer for this integration. This integration shall be done via BACnet IP or BACnet MSTP if BACnet IP is not available.
3. Typical Software Points shall be as follows:

Point	Type	Alarm	Short Term Trend	Long Term Trend	On BMS Graphic
Allow for a minimum of 30 points	TBD	TBD	TBD	TBD	Yes

C. VFD(s)

1. The BMS shall be able to start and stop and control the VFD speed via a hardwired point based on the sequence of operations program.
2. The communication interface shall allow the BMS read capabilities.
3. It shall be the responsibility of the BMS contractor to review requirements and coordinate with the approved submittal from the VFD manufacturer for this integration. This integration shall be done via BACnet IP where available or BACnet MSTP if BACnet IP is not available.
4. Typical Software Points shall be as follows:

Point	Type	Alarm	Short Term Trend	Long Term Trend	On BMS Graphic
Start / Stop	DO	No	Yes	Yes	Yes
Speed Modulation	AO	No	Yes	Yes	Yes
Status (Current Sensor)	AI	Yes	Yes	Yes	Yes
VFD Fault	DI	Yes	Yes	Yes	Yes
HOA Not in Auto	DI	Yes	Yes	Yes	Yes
VFD in Bypass	DI	Yes	Yes	Yes	Yes
Forward / Reverse Status	SW	No	No	No	Yes
Drive Ready Status	SW	No	No	No	Yes
At Setpoint Status	SW	No	No	No	Yes
Resets Faults	SW	No	No	No	Yes
Output Speed min-1	SW	No	No	No	Yes
Output Frequency Hz	SW	No	No	No	Yes
DC Bus Voltage V	SW	No	No	No	Yes
Motor Voltage V	SW	No	No	No	Yes
Motor Current A	SW	No	No	No	Yes
Motor Torque %	SW	No	No	No	Yes
Motor Power %	SW	No	No	No	Yes
Drive Thermal State %	SW	No	No	No	Yes
Energy Counter kWh	SW	No	No	No	Yes
Run Time	SW	No	Yes	Yes	Yes
Last Error Code	SW	No	No	No	Yes

D. Split Air Conditioning Units /Computer Room Air Conditioning (CRAC) Units

1. The communication interface shall allow the BMS read capabilities.
2. It shall be the responsibility of the BMS contractor to review requirements and coordinate with the approved submittal from the CRAC manufacturer for this integration. This integration shall be done via BACnet IP or BACnet MSTP if BACnet IP is not available.
3. Typical Software Points shall be as follows:

Point	Type	Alarm	Short Term Trend	Long Term Trend	On BMS Graphic
Space Temperature	SW	Yes	Yes	Yes	Yes
Space Humidity	SW	Yes	Yes	Yes	Yes
Unit Status	SW	No	Yes	Yes	Yes
Unit Runtime	SW	No	Yes	Yes	Yes
General Alarm	SW	Yes	Yes	Yes	Yes

E. Packaged Air Handling Unit

1. The communication interface shall allow the BMS read capabilities.
2. It shall be the responsibility of the BMS contractor to review requirements and coordinate with the approved submittal from the equipment manufacturer for this integration. This integration shall be done via BACnet IP or BACnet MSTP if BACnet IP is not available.
3. Typical Software Points shall be as follows:

DIRECT DIGITAL CONTROL (DDC) SYSTEM FOR HVAC

Point	Type	Alarm	Short Term Trend	Long Term Trend	On BMS Graphic
Allow for a minimum of 30 points	TBD	TBD	TBD	TBD	Yes

F. Fuel Oil System

1. The communication interface shall allow the BMS read capabilities.
2. It shall be the responsibility of the BMS contractor to review requirements and coordinate with the approved submittal from the equipment manufacturer for this integration. This integration shall be done via BACnet IP or BACnet MSTP if BACnet IP is not available.
3. Typical Software Points shall be as follows:

Point	Type	Alarm	Short Term Trend	Long Term Trend	On BMS Graphic
Allow for a minimum of 45 points	TBD	TBD	TBD	TBD	Yes

G. Electric Power Meters and EPMS

1. The communication interface shall allow the BMS read capabilities.
2. It shall be the responsibility of the BMS contractor to review requirements and coordinate with approved submittal from the equipment manufacturer for this integration. This integration shall be done via BACnet IP or BACnet MSTP if BACnet IP is not available.
3. BMS shall monitor and store both total production and power output data from meters at minimum 5-minute intervals.

2.15 INFORMATION REDIRECTION

- A. It shall be possible for the system to redirect information to other locations and/or printers on a time schedule basis (including holiday programming) or manual command basis.

2.16 RESPONSE TIMES

- A. The response times detailed below are the maximum acceptable response times.
- B. Alarms: The time from activation of an alarm (at the source) to annunciation on an operator's station, printer or to another DDC controller shall not exceed 10 seconds.
- C. Graphic Displays: A graphic display shall be displayed complete with updated information from the field for all points, within 15 seconds of the operator request.
- D. Once displayed all point information will be updated from the field and displayed at intervals not exceeding 30 seconds.

- E. Logical Groups: A logical group shall be displayed complete with updated information from the field for all points within 15 seconds of the operator's request. Once displayed the value shall be refreshed every 10 seconds.
- F. Selected Points: The field value of a single input, output or virtual point shall be displayed on the operator's station screen within 5 seconds of a request.
- G. Global Program: the time from occurrence of an event from one controller or unitary controller to the activation of the output of another controller or unitary controller shall not exceed 10 seconds.

2.17 TRANSIENT/SPIKE PROTECTION

- A. Suppressors shall be fitted to all controller input points for protection against voltage transients, spikes etc.
- B. The communication network(s), the BLN and the FLN, shall be isolated against transient disturbances via optical couplers or other approved means. Where running between buildings, lightning protection devices shall be installed on the communications network at the point of entry to each building.

2.18 ELECTROMAGNETIC PROTECTION

- A. All components of BMS and the entire BMS system shall comply with the requirements of the relevant Emission and Immunity Standards.
- B. In order to avoid corruption of the BMS equipment operation by electrical interference, all wiring shall be installed to minimize coupling of electromagnetic and electrostatic interference on low voltage signals and data wiring. Where mixed wiring is unavoidable braided screen mains cable, dressed close to metalwork, is preferred, but the Tendered shall clearly specify the methods by which he intends to eliminate any such interference with his signal and data transmission.
- C. The BMS shall be protected from interference by the operation of hand held radio transmitters, radio pagers, etc. within 1 meter of the equipment.

2.19 BMS STANDARD PROGRAMS

- A. The device schedules included in this Specification provide details of inputs monitored and outputs controlled by the BMS. All point types are described in the section covering DDC Controllers in this Specification. The BMS system shall allow for the following point functionality and standard programs to be available:
 - 1. Point Override
 - 2. Manual Start/Stop
 - 3. Fixed Time Program

4. Optimum Start/Stop – program shall calculate the optimum start time for plant systems, e.g. the AHU, based on occupancy time and on internal space and outside conditions.
5. Control Loops
6. Rotational Point
7. Run Time Totalization
8. Anti-short Cycling
9. Staggered Start
10. User Definable Software
11. General Control Requirements

2.20 FIELD DEVICES

A. General

1. All control signals shall be via 4-20 mA or 0-10 VDC loops.
2. It is the contractor's responsibility to properly select all instruments for process and application suitability, inclusive of materials and operating ranges.
3. Input/Output sensors and devices shall be closely matched to the requirements of the BMS for accurate, responsive, noise-free signal input/output. Control input response shall be highly sensitivity and matched to the loop gain requirements for precise and responsive control. Provide the following instrumentation as required by the monitoring, control and optimization functions.

B. Temperature Sensors/Transmitters/Thermowells

1. Thermistors based temperature sensors shall be paired with a 4 wire 4-20 mA output transmitter. Transmitter shall have built-in circuit protection against reverse polarity and supply voltage transients.
2. RTD based temperature sensors shall use platinum elements only, nickel or silicon RTDs are not acceptable.
3. Air stream averaging type
 - a. The assembly shall consist of a capillary type element, housed in a flexible sheath contained in housing suitable for duct mounting.
 - b. Probe length: 1 ft./4 square ft. of duct area
 - c. All duct cross sections greater than 10 square feet to have serpentine-averaging element to adequately average stratified air temperature.
 - d. Temperature Monitoring Range: +20 to +120°F
 - e. Factory calibration point: 70°F.
 - f. Accuracy: ± 0.5 °F.
4. Air stream insertion / non-averaging type.
 - a. The assembly shall consist of an insertion type element contained in a housing suitable for duct mounting and mounted on probe whose maximum length shall be 12 inches or $\frac{1}{2}$ duct diameter, whichever is smaller.
 - b. Temperature Monitoring Range: +20 to +120°F
 - c. Factory calibration point: 70°F.
 - d. Accuracy: ± 0.5 °F.

- e. For outside air applications, mount with weather protection and sun shield.
- 5. Space monitoring type - Traditional
 - a. The assembly shall consist of an element contained in a ventilated enclosure.
 - b. Temperature Monitoring Range: +20 to +120°F
 - c. Factory calibration point: 70°F.
 - d. Accuracy: ± 0.5 °F.
 - e. Provide low profile combination temperature and humidity sensors for Gallery/Exhibit Areas as applicable
 - f. Coordinate Temperature Sensor faceplate requirements with architect/owner and engineer. Faceplates options shall include color, blank faceplate option, display faceplate option, setpoint adjustment option and occupied/unoccupied override option) Submit for approval.
- 6. Space monitoring type – Wall Mounted Button/Bullet Sensor
 - a. Sensors are to provide space temperature via hardwired connection.
 - b. The assembly shall consist of a stainless steel button wall mounted style sensor/element.
 - c. Temperature Monitoring Range: +20 to +120°F
 - d. Factory calibration point: 70°F.
 - e. Accuracy: ± 0.5 °F.
- 7. Space monitoring type – Electric /Line Voltage Thermostats
 - a. Furnish and install all line voltage thermostats for unit heaters.
 - b. Thermostats contacts shall be rated for maximum heater amperage and shall be snap acting, SPDT.
 - c. Thermostat cover shall provide exposed set point and key adjust.
 - d. When used for unit heaters - Furnish and install strap on aquastats to prevent unit heaters from operating without hot water or steam
- 8. Liquid insertion type
 - a. The assembly shall be provided with a housing suitable for pipe mounting.
 - b. The transmitter shall be compatible with the temperature element and the DDCP.
 - c. Transmitter shall have built-in circuit protection against reverse polarity and supply voltage transients.
 - d. Include a stainless steel thermowell, maximum length shall be 6 inches or 3/4 of pipe diameter, whichever is smaller.
 - e. Temperature Monitoring Range: The sensor range shall be suitable to the process being monitored.
 - f. Factory calibration point: Middle of process range.
 - g. Accuracy: ± 0.5 °F.
- 9. Outside Air Assembly
 - a. The assembly shall be contained in an enclosure suitable for outdoor applications.
 - b. Temperature Monitoring Range: -50 to +120°F
 - c. Factory calibration point: 70°F.
 - d. Accuracy: ± 0.5 °F.
- 10. Averaging Temperature RTD for Cooling tower basin

- a. A multipoint RTD capable of monitoring a multitude of temperatures over a vertical length as specified to cover depth of cooling tower basins.
 - b. Sensor shall be paired with a transmitter capable of an averaging process and 4-20mA output to the BMS.
 - c. Include a stainless steel thermowell.
 - d. Transmitter shall have built-in circuit protection against reverse polarity and supply voltage transients. Transmitter shall be a two wire device, loop powered.
 - e. Assembly shall be coordinated with cooling tower basing manufacturer to allow for proper mounting hardware installation. All mounting hardware to be provided by Controls contractor.
 - f. Manufacturer – Moore Industries.
11. Freezestats
- a. Furnish and install for each air handling unit with outdoor air connections, a low temperature safety thermostat (freezestat) with 20 ft sensing element installed in a serpentine fashion across the inlet of the cooling coil (one freezestat per coil section) in the air stream arranged to stop the unit supply fan and its associated return air fan should the temperature at any point along the sensing element fall below 39°F (adjustable) for an adjustable time period.
 - b. Low temperature detector shall be automatic reset, DPDT type unless specified in sequences within specification.
 - c. Provide manufacturer specified / acceptable clips for recommended support.
12. Thermowells
- a. Provide a Thermowell for every thermistor temperature sensing element installed in piping and equipment. Provide a separate calibration thermowell for every thermistor. Refer to installation detail shown on drawings.
 - b. Thermowells shall be Type 304 stainless steel, or brass tapered pattern, 3/4 inch NPT external process connection, 1/2 inch NPT internal thread, with lagging extension, equal to insulation thickness, where installed in insulated piping. Thermowells shall have an insertion length of at least 1/3 of pipe diameter but in no case shall wells be less than 4-1/2 inch insertion length. Maximum immersion length shall be 6 inches or 3/4 of pipe diameter, whichever is smaller. Thermowells shall be rated for maximum system operating pressure, temperature and fluid velocity.
 - c. Internal bore of Thermowells shall be sized to exactly fit the diameter of the sensing element to be installed.
 - d. Provide necessary thermally conductive material for proper sensor to thermowell contact.
13. Smart Sensors (for Residences)
- a. The assembly shall consist of an element contained in a ventilated enclosure.
 - b. Temperature Monitoring Range: +20 to +120°F
 - c. Factory calibration point: 70°F.
 - d. Accuracy: ± 0.5 °F.
 - e. Unit shall be capable of occupancy monitoring. Sensor shall use either passive infrared or ultrasonic technology with sensitivity adjustment

- f. Unit shall be classified as a Terminal Equipment Controller, refer to specific section for additional requirements.
- g. Provide functionality (inclusive of hard wired outputs) required to control residence unit heating and cooling valves. In accordance with design details and sequence of operations.
- h. Coordinate Temperature Sensor faceplate requirements with architect/owner and engineer. Faceplates options shall include color, blank faceplate option, display faceplate option, setpoint adjustment option and occupied/unoccupied override option) Submit for approval.

C. Pressure Sensors/Transmitters/Switches

- 1. Air Differential Pressure Switch
 - a. Differential pressure switches shall be diaphragm type, with die-cast aluminum housing and an adjustable set point.
 - b. Output: Switches contact shall be DPDT and rated a minimum of 5 amps at 120 VAC.
 - c. Switch pressure range shall be suited for application (e.g. filter 0-2.0", fan status 0-5.0", etc.).
 - d. Sensor shall be adjustable for zero and span.
 - e. All exposed tubing shall be capped with static pressure tips.
- 2. Air Differential Pressure Transmitter
 - a. Sensors shall be suitable for low pressures likely to be encountered and be selected for approximately 50% over range and have 4-20ma output.
 - b. Connect to measuring points with valved lines for testing and calibration.
 - c. Sensors shall be adjustable for zero and span.
 - d. Sensors for VFD fan control shall be located 2/3rds downstream of fan.
 - e. All exposed tubing shall be capped with static pressure tips.
- 3. Air Static Pressure Transmitter
 - a. Sensors shall be suitable for low pressures likely to be encountered and be selected for approximately 50% over range and have
 - b. Output: 4-20 mA
 - c. Connect to measuring points with valved lines for testing and calibration.
 - d. Sensors shall be adjustable for zero and span.
 - e. Sensors shall be located 2/3rds downstream of index run.
 - f. All exposed tubing shall be capped with static pressure tips.
- 4. Water Pressure / Differential Pressure Switch
 - a. Switches shall be diaphragm actuator type, with epoxy coated aluminum housing and an adjustable set point.
 - b. Output: Switch contact shall be SPDT, 15A 120VAC.
 - c. Switch pressure range shall be suited for application
 - d. Actuator seal to be compatible with process temperature limits
 - e. Accuracy : 1% of nominal range
 - f. Sensor shall be adjustable for zero and span.
 - g. Manufacturer: Ashcroft
- 5. Water Pressure / Differential Pressure Transmitter
 - a. Provide a variable capacitance 2-wire, 4-20 mA differential pressure transmitter assembly. Differential pressure transmitters shall be enclosed in a gasketed, dust and watertight housing. All body cavities

- open to the process fluid shall be provided with drain ports at the cavity bottom and vent ports at the top of the cavity. Both drain and vent ports shall be minimum ¼ inch – 18 NPT.
- b. The transmitter shall have continuously adjustable (externally) zero and span. These adjustments shall be made within the transmitter housing without a change of parts.
 - c. The transmitter shall be capable of sustaining differential pressures in either direction, up to the body rating without damage to the instrument or a loss of accuracy or zero shift.
 - d. The transmitter shall be fully compensated for both process and ambient temperature variations and a calibrated accuracy of $\pm 0.25\%$ of calibrated span.
 - e. Provide local LCD display and wire-on-tag with instrument service information.
 - f. Provide manufacturers standard 316 stainless steel, 5-valve manifold and pressure gauges for supply and return pressures.
 - g. Manufacturer: Rosemount 3051S, 316 stainless steel or approved equal.
6. Building Pressurization System
- a. System layout shall include: both indoor and outdoor sensor locations with mounting design; where fire-rated penetrations are required in walls or ceilings with reference to penetration details which describe material transitions as required; where plenum-rated tubing is required; locations of control panels; requirements for power provided under Division 26; zone pressure sensors shall not be located near mailroom exhaust, kitchen hood exhaust, AHU return ducts, medical lab exhaust hoods, or other sources of positive or negative pressure which will adversely affect the stability and accuracy of the sensor readings
7. Indoor Pressure Pickup Ports
- a. Wall mount: Plate compatible with J-box.
 - b. Ceiling mount: Plate compatible with J-box or designed to fit a ¾" thick suspended ceiling tile.
 - c. Brushed stainless steel with gasket seals.
 - d. Brass fitting for standard 1/8" to 5/32" I.D. tubing.
 - e. Equal to Building Automation Products, Inc. ZPS-ACC.
8. Outdoor Static Pressure Pickup Ports
- a. Wall or roof mount.
 - b. UV resistant and flame retardant plastic housing.
 - c. ½" EMT conduit connection.
 - d. Barbed fitting for standard 1/8" to 5/32" I.D. tubing
 - e. Rated for -40 to 212°F, 0-100% non-condensing.
 - f. Equal to Building Automation Products, Inc. ZPS-ACC-10.
9. Outdoor Static Pressure Manifold Enclosure
- a. Wall mounted, weatherproof (NEMA 3 or 4), steel enclosure.
 - b. Powder coated finish.
 - c. Hinged door.
 - d. Oil resistant door gasket.
 - e. Accessories:
 - 1) Powder coated, heavy gauge steel louvers, one per side for minimum 2 inch by 1.75 inch panel opening.

- 2) Lockable door latch.
- 3) Insect screen on over louver openings inside of enclosure.

D. Flow Sensors/Transmitters/Switches

1. Through the wall Airflow Measurement Device:
 - a. Provide through the wall airflow measuring device for the monitoring air flow between the Fan Rom #1 and the adjacent corridor and Fan Rom #2 and the adjacent corridor as shown on mechanical and controls drawings.
 - b. Each measuring device shall consist of one sensor and one transmitter to maintain specified accuracy and performance.
 - c. A single manufacturer shall provide both the airflow measuring sensor and transmitter.
 - d. The operating airflow range shall be 0 fpm to 5,000 fpm. . The operating environmental range for the airflow probes shall be 20°F to 140°F, 99% R (non-condensing).
 - e. The operating environmental range of the transmitter shall be 30°F to 120°F protected from the weather.
 - f. The sensor shall have an accuracy of $\pm 2\%$ of reading over the entire operating range and be fully temperature compensated.
 - g. Provide a 4-20 ma transmitter for interface to the BMS system.
 - h. Provide all necessary hardware including, stainless steel faceplate with protective mesh, hose barbs, extensions, copper tubing, bleed sensor assembly, fittings, transmitter and panel enclosure.
 - i. Installation method shall be coordinated with device manufacturer and approved by Owner and Controls Engineer prior to any and all work.
 - j. Acceptable manufacturers:
 - 1) Ebtron Inc (Gold Series)including GB1/SB1Bleed Sensors
2. Air Flow Measurement Stations - Fan Inlet and Outside Air Intake / Exhaust Air Flow
 - a. General: The airflow measurement stations shall be capable of monitoring airflow and temperature rates at each measurement location. The system shall be factory tested prior to shipment and shall not require calibration or adjustment over the life of the equipment, when installed in accordance to manufacturer's guidelines.
 - b. Provide fan inlet and outdoor airflow measuring devices for air handling units as shown on drawings. Each airflow measuring device shall consist of multiple measuring probes.
 - c. Installed accuracy shall be percent of reading and demonstrated at both maximum and minimum airflow rates for each measurement location..
 - d. The operating airflow range shall be 0 fpm to 5,000 fpm. .
 - e. A single manufacturer shall provide both the airflow measuring probe and transmitter.
 - f. Sensor assembly
 - 1) Each sensing point shall independently measure airflow and temperature prior to averaging. Sensors shall be calibrated to NIST-traceable standards for both airflow and temperature. Heated element, bead in glass hermetically sealed thermistor probes.
 - 2) Provide quantity of probes to meet manufacturer's minimum installation requirements. Provide quantity of airflow measuring probes to maintain specified accuracy and performances.

- 3) Each airflow measuring device shall consist of multiple measuring probes. Provide quantity of airflow measuring probes to maintain specified accuracy and performances.
 - 4) The operating environmental range for the airflow probes shall be -20 deg f to 160 deg f, 100% R (non-condensing).
 - 5) The sensor shall have an accuracy $\pm 2\%$ of reading over the entire operating range and be fully temperature compensated.
 - g. Transmitter and Electronics Enclosure
 - 1) The transmitter shall operate on 24 VAC. The transmitter shall have a minimum 16 character alphanumeric LCD display for airflow, temperature, and system diagnostics. Analog output signals shall be user selectable (0-10 VDC or 4-20 mA). All inputs and outputs shall be fused, protected, and internally isolated from the 24 VAC power supply. The transmitter shall have a non-drifting adjustment for output signal offset/gain. The transmitter display shall be capable of being configured in either I.P. or S.I. units. The transmitter shall accept a user-defined area to display volumetric flow rates in CFM.
 - 2) The enclosure shall be aluminum alloy for indoor use and capable of operating over a temperature range of -20° F to +120° F. The electronics shall be installed inside and protected from the weather. Exterior installation or areas acceptable to high levels of moisture use NEMA4 enclosure.
 - h. Temperature Output to BMS
 - 1) Provide temperature monitoring output to BMS in accordance with mechanical drawings.
 - i. Acceptable manufacturers:
 - 1) Ebtron, Inc (Gold Series)
 - j. BMS contractor shall employ or subcontract factory trained Ebtron technician as part of this contract to assist in design and to inspect all outside air measurement installations and assist in calibrating and adjusting the Ebtron outside air sensors as required to meet final balancing setting to provide accurate BMS monitoring and control.
3. Air Flow Measurement Stations - Fan Array
 - a. Probe and Sensor Node Configurations
 - 1) Fan Arrays (less than or equal to 4 fans): 2 probes x 1 sensor node per probe or 1 probe x 1 sensor node per probe in each fan
 - 2) Fan Arrays (greater than 4 fans): 1 probe x 1 sensor node per probe in each fan (8 probe maximum)
 - b. Installed Airflow Accuracy
 - 1) $\pm(3\%$ to $10\%)$ of reading, depending on fan type and installation.
 - c. Sensor Node Averaging Method
 - 1) Airflow: Independent, arithmetic average per fan
 - 2) Temperature: Independent, velocity weighted average
 - d. Listings and Compliance
 - 1) UL: UL-873 and CSA C22.2 No. 24
 - 2) BACnet International: BTL Listed (GTC108 and GTM108 transmitters)
 - e. Environmental Limits
 - 1) Temperature:

- a) Probes: -20 to 160 °F [-28.9 to 71.1 °C]
- b) Transmitter: -20 to 120 °F [-28.9 to 48.9 °C]
- 2) Humidity: (non-condensing)
- 3) Probes: 0 to 100%
- 4) Transmitter: 5 to 95%
- f. Sensing Node Sensors
 - 1) Self-heated sensor: Precision, hermetically sealed, bead-in-glass thermistor
 - 2) Temperature sensor: Precision, hermetically sealed, bead-in-glass thermistor
- g. Sensing Node Housing
 - 1) Material: Glass-filled Polypropylene
 - 2) Sensor Potting Materials: Waterproof marine epoxy
- h. Airflow Measurement
 - 1) Accuracy: $\pm 2\%$ of reading to NIST-traceable airflow standards (includes transmitter uncertainty)
 - 2) Calibrated Range: 0 to 10,000 fpm [0. to 50.8 m/s]
 - 3) Calibration Points: 16
 - 4) Temperature Measurement
 - 5) Accuracy: ± 0.15 °F [0.08 °C] to NIST-traceable temperature standards (includes transmitter uncertainty)
 - 6) Calibrated Range: -20 to 160 °F [-28.9 to 71.1 °C]
 - 7) Calibration Points: 3
- i. Sensor Probe Assembly
 - 1) Mounting Rods
 - a) Material: Zinc plated steel
 - 2) Mounting Brackets
 - a) Material: 304 stainless steel
 - 3) Probe to Transmitter Cables
 - a) Type: FEP jacket, plenum rated CMP/CL2P, UL/cUL listed, -67 to 302 °F [-55 to 150 °C], UV tolerant
 - b) Standard Lengths: 10, 25, and 50 ft. [3.1, 7.6 and 15.2 m]
 - 4) Connecting Plug: 9/16" [14.29 mm] nominal diameter with gold-plated connector pins
- j. Power Requirement:
 - 1) 24 VAC (22.8 to 26.4 under load) @16V-A
- k. User Interface:
 - 1) 2 line x16-character backlit LCD display and 4 button interface
- l. BMS Connectivity
 - 1) All Transmitter: Three field selectable (0-5/0-10 VDC or 4-20mA), scalable and isolated analog output signals (AO1=airflow,AO2=temperature or alarm, AO3=Not used.
 - 2) GTC108e Transmitter: One additional field selectable (BACnet MS/TP or Modbus RTU) and isolated RS-485 network connection - Individual sensor node airflow rates and temperatures are available via the network (as applicable)

- 3) GTM108e Transmitter: One additional isolated Ethernet (simultaneously supported BACnet Ethernet or BACnet IP, Modbus TCP and TCP/IP) network connection – Individual sensor node airflow rates and temperatures are available via the network
- m. Airflow Alarm
 - 1) Type: Low and/or high user defined setpoint alarm
- n. Tolerance: User defined % of setpoint
- o. Delay: User defined
- p. Zero Disable: Alarm can be disabled when the airflow rate falls below the low limit cutoff value (unoccupied periods)
- q. Reset Method: Manual or automatic
- r. Visual Indication: Yes, LCD display
- s. Network Indication: Yes (GTM108 and GTC108 only)
- t. Analog Signal Indication: Yes, on AO2 assignment
- u. Fan Alarm
 - v. Type: Minimum airflow, % deviation from median airflow, or % deviation from maximum airflow stored in memory
 - w. Tolerance: User defined % of setpoint
 - x. Delay: User defined
 - y. Zero Disable: Alarm can be disabled when the airflow rate falls below the low limit cutoff value (unoccupied periods)
 - z. Reset Method: Manual or automatic
 - aa. Visual Indication: Yes, LCD display
 - bb. Network Indication: Yes (GTM108 and GTC108 only)
 - cc. Analog Signal Indication: Yes, on AO2 assignment
- dd. System Status Alarm
 - ee. Type: Sensor diagnostic system trouble indication
 - ff. Visual Indication: Yes, LCD display
 - gg. Network Indication: Yes
 - hh. Analog Signal Indication: Yes, on AO2 assignment
 - ii. EB-Link Bluetooth Interface for Android® and iPhone®:
 - jj. Download individual sensor node airflow/temperature data, settings and diagnostics
- 4. Airflow/Temperature Measurement Devices
 - a. Provide airflow/temperature measurement devices (ATMD) where indicated on the plans and/or schedule.
 - b. Fan inlet measurement devices shall not be substituted for duct or plenum measurement devices unless an authorized EBTRON representative deems duct work to be too restrictive for probes. Written authorization is required by EBTRON and the specifying engineer.
 - c. FLOW STATION CONSTRUCTION:
 - 1) Each ATMD shall consist of one or more sensor probes and a single, remotely mounted, microprocessor-based transmitter capable of independently processing up to 16 independently wired sensor assemblies.
 - 2) Each sensor assembly shall contain two individually wired, hermetically sealed bead-in-glass thermistors.
 - 3) Thermistors shall be mounted in the sensor assembly using a marine-grade, waterproof epoxy. Thermistor leads shall be protected and not exposed to the environment.

- 4) The airflow rate of each sensor assembly shall be equally weighted and averaged by the transmitter prior to output.
 - 5) The temperature of each sensor assembly shall be velocity weighted and averaged by the transmitter prior to output.
 - 6) Each transmitter shall have a 16-character alpha-numeric display capable of displaying airflow, temperature, system status, configuration settings and diagnostics.
 - 7) Devices using chip-in-glass or diode-case chip thermistors are not acceptable.
 - 8) Devices using less than two thermistors in each sensor assembly are not acceptable.
 - 9) Devices using platinum wire RTDs are not acceptable.
 - 10) Devices having electronic circuitry mounted in or at the sensor probe are not acceptable.
 - 11) Pitot tubes and arrays are not acceptable.
 - 12) Vortex shedding devices are not acceptable.
- d. ALL SENSOR PROBES
- 1) Each sensor assembly shall independently determine the airflow rate and temperature at each measurement point.
 - 2) Each sensor assembly shall be calibrated at a minimum of 16 airflow rates and 3 temperatures to standards that are traceable to the National Institute of Standards and Technology (NIST).
 - 3) Airflow accuracy shall be $\pm 2\%$ of Reading over the entire operating airflow range.
 - 4) Devices whose accuracy is the combined accuracy of the transmitter and sensor probes must demonstrate that the total accuracy meets the performance requirements of this specification throughout the measurement range.
 - 5) Temperature accuracy shall be $\pm 0.15^\circ \text{F}$ over the entire operating temperature range of -20°F to 160°F .
 - 6) The operating humidity range for each sensor probe shall be 0-99% RH (non-condensing).
 - 7) Each sensor probe shall have an integral, U.L. listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. All terminal plug interconnecting pins shall be gold plated.
 - 8) Each sensor assembly shall not require matching to the transmitter in the field.
 - 9) A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter for each measurement location.
- e. DUCT AND PLENUM PROBES
- 1) Probes shall be constructed of extruded, gold anodized, 6063 aluminum tube. All wires within the aluminum tube shall be Kynar coated.
 - 2) Probe assembly mounting brackets shall be constructed of 304 stainless steel. Probe assemblies shall be mounted using one of the following options:
 - 3) Insertion mounted through the side or top of the duct
 - 4) Internally mounted inside the duct or plenum
 - 5) Standoff mounted inside the plenum

- 6) The number of sensor housings provided for each location shall be as follows:

f.	Duct or Plenum Area (sq.ft.)	h.	Total # Sensors / Location
i.	<2	j.	4
k.	2 to < 4	l.	6
m.	4 to < 8	n.	8
o.	8 to <16	p.	12
q.	>=16	r.	16

- 1) The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.

s. TRANSMITTERS

- 1) The transmitter shall have an integral LCD display capable of simultaneously displaying airflow and temperature. The LCD display shall be capable of displaying individual airflow and temperature readings of each independent sensor assembly.
- 2) The transmitter shall be capable of field configuration and diagnostics using an on-board pushbutton interface and LCD display.
- 3) The transmitter shall have a power switch and operate on 24 VAC (isolation not required).
- 4) The transmitter shall use a switching power supply fused and protected from transients and power surges.
- 5) The transmitter shall use "watch-dog" circuitry to assure reset after power disruption, transients and brown-outs.
- 6) All interconnecting pins, headers and connections on the main circuit board, option cards and cable receptacles shall be gold plated.
- 7) The operating temperature range for the transmitter shall be -20° F to 120° F. The transmitter shall be installed at a location that is protected from weather and water.
- 8) The transmitter shall be capable of communicating with other devices using one of the following interface options:
- 9) Linear analog output signals for airflow and temperature: Field selectable, fuse protected and isolated, 0-10VDC/4-20mA (4-wire)
- 10) RS-485: Field selectable BACnet-ARCNET, BACnet-MS/TP, Modbus-RTU or Johnson Controls N2-Bus
- 11) BACnet devices shall provide analog variables for airflow and temperature containing individual sensor airflow rate and temperature data.
- 12) 10 Base-T Ethernet: Field selectable BACnet Ethernet, BACnet-IP, Modbus-TCP and TCP/IP
- 13) Provide dynamic link libraries and VBA functions to interface Ethernet devices to Microsoft Excel for remote monitoring of airflow and temperature using a Windows 2000 or Windows XP based PC.
- 14) LonWorks Free Topology
- 15) The transmitter shall be capable of accepting an infra-red interface card for downloading airflow and temperature data or uploading

transmitter configuration data using a handheld PDA (Palm or Microsoft Windows Mobile operating systems).

- 16) Provide PDA upload/download software.
- 17) Download software shall be capable of displaying and saving individual sensor airflow rates, the average airflow rate, individual sensor temperatures and the average temperature received from the transmitter.
- 18) Upload software shall be capable of displaying and saving all setup parameters that can be configured using the on-board pushbutton interface and LCD display.
- 19) Provide a Microsoft Excel file capable of creating balance reports from PDA data files transferred to a Windows 98 or higher based PC.
- 20) Provide a Microsoft Excel file to create configuration data files that can be transferred from a Windows 2000, Windows XP or higher based PC to a PDA for upload to one or more transmitters.
- 21) The ATMD shall be UL listed as an entire assembly.
- 22) The ATMD shall carry the CE Mark for European Union shipments.
- 23) The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans.
- 24) A written report shall be submitted to the consulting mechanical engineer if any measurement locations do not meet the manufacturer's placement requirements.

t. INSTALLATION

- 1) Install airflow / temperature measurement devices in accordance with manufacturer's instructions at the locations indicated on the plans.
- 2) A written report shall be submitted to the consulting mechanical engineer if any discrepancies are found.
- 3) Install labels and nameplates to identify control components according to Section 23 33 00 or 25 35 00.
- 4) Install electronic cables according to Section 25 05 00 "Common Work Results for Integrated Automation."
- 5) Install low-voltage power, signal and communication cable according to Sections 25 05 13 "Conductors and Cables for Integrated Automation," 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" and/or 27 15 00 "Communications Horizontal Cabling."

u. ADJUSTING

- 1) Duct and plenum devices shall not be adjusted without approval from the consulting mechanical engineer.

v. ACCEPTABLE MANUFACTURERS

- 1) Subject to compliance with requirements of this Section, provide products that comply with this specification by one of the following vendors:
- 2) EBTRON, Inc. Model GTx116-P (basis of design)
- 3) Kurz Instruments
- 4) Fluid Components International (FCI)
- 5) Alternatives requesting acceptance as "equals" less than 60 days prior to bid date or products submitted in non-conformance with the

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requirements of this specification will not be considered. For any product to be considered for substitution a written section-by-section detailed exceptions/compliance document shall be submitted to the Engineer before any approval will be considered. Before a product can be considered as an equal to EBTRON for substitution to this specification, a "non-fan powered" working demo must be made available for a side by side evaluation to EBTRON in the specifying engineer's office. The products must demonstrate accurate airflow measurement, repeatability and response time as well as specification compliance. Providing a working demo in and of itself does not constitute the products approval.

5. Liquid Flow - Magnetic Flow Meter
 - a. The flow transmitter shall be a full sized magnetic flow meter.
 - b. The flow meter shall be field-programmable with all site criteria being capable of input or change on-site by the use of plug-in hand-held terminal. All programming will be menu-driven and input in plain English.
 - c. System Requirements
 - 1) Intrinsic Accuracy: Within 1 percent of actual flow above 1 fps.
 - 2) Calibrated Accuracy: 0.5 percent of actual flow above 1 fps.
 - 3) Flow Range Ability: Bidirectional including active zero sensitivity.
 - 4) Sensitivity: 0.001 ft./sec.
 - 5) Respectability: High precision: 0.15%.
 - d. Flow Transmitter
 - 1) The flow transmitter shall be solid state design utilizing high reliability circuit elements and compound shall be micro-computer controller. The transmitter shall be housed in a NEMA 4X enclosure suitable for remote mounting. The transmitter shall be furnished with built-in fault alarm, and self diagnostic program to accurately track the metering systems performance. The programming shall be battery backed in RAM.
 - 2) The transmitter shall be equipped with an isolated 4-20 ma output signal, proportioned to flow, and be able to drive a restive load of up to 800ohms.
 - e. The flow meter shall be provided will flow sizing calculation data.
 - f. Manufacturer / Model
 - 1) Rosemount / Sensor Model 8705, Transmitter Model 8732C
- E. Energy Metering System
 1. Water Metering System
 - a. Liquid Flow - Magnetic Flow Meter
 - 1) The flow transmitter shall be a full sized magnetic flow meter.
 - 2) System Requirements
 - a) Intrinsic Accuracy: Within +/-0.25 percent of actual flow 0.04 to 6 fps
 - b) Flow Range Ability: Bidirectional including active zero sensitivity.

- c) Sensitivity: 0.001 ft./sec.
- d) Repeatability: High precision: 0.15%.
- 3) Flow Transmitter
 - a) The flow transmitter shall be solid state design utilizing high reliability circuit elements and compound shall be micro-computer controller. The transmitter shall be housed in a NEMA 4X enclosure suitable for remote mounting. The transmitter shall be furnished with built-in fault alarm, and self-diagnostic program to accurately track the metering systems performance. The programming shall be battery backed in RAM.
 - b) The transmitter shall be equipped with an isolated 4-20 ma output signal, proportioned to flow, and be able to drive a restive load of up to 800ohms.
- 4) The flow meter shall be provided will flow sizing calculation data.
- 5) The flow meter shall be field-programmable with all site criteria being capable of input or change on-site by the use of plug-in hand-held terminal. All programming will be menu-driven and input in plain English.
- 6) Manufacturer / Model
 - a) Rosemount / Sensor Model 8705, Transmitter Model 8732C
- b. Precision matched RTDs: 1,000 ohm platinum
 - 1) Differential Temperature Accuracy: 0.2 Deg F (with ice bath calibration).
 - 2) Transducers: (High Temperature)
- c. Installation, programming and Start-Up
 - 1) The manufacturer and/or factory representative of the energy meter shall provide field supervision at the project site for the installation of the metering equipment. The manufacturer and/or factory representative of the meter shall provide on-site programming of the meter, installation check and commissioning of the meter.
- d. Energy Meter
 - 1) Provide a Kessler Ellis Products Supertroll II energy flow meter (with matched supply and return temperature sensors) for hot and chilled water BTU measurement applications.
 - 2) Provide local LCD display and wire-on-tag with instrument service information.
 - 3) NEMA 4X front.
 - 4) The computer shall have on board self-diagnostics, and ROM based stored fluid properties for water.
 - 5) The computer shall be capable of a Modbus RTU output for all the device parameters monitored including, but not limited to instantaneous flow.
 - 6) Energy meter shall be provided with manufacturer's gateway to convert meter data from Modbus/RTU to BACnet/MSTP for compatibility with BMS.

e. Training

- 1) The manufacturer and factory representative of the flow-meter shall provide a minimum of one half-day of operation orientation and instruction on the operation of the flow-meter consecutive with the installation of the flow meter.

F. Miscellaneous Sensors

1. Humidity Sensors

- a. The assembly shall consist of a humidity sensor utilizing a resistance change bulk polymer sensing element mounted in a housing suitable for the following applications – Outdoor, Return, and Space.
- b. Sensor Humidity Operating Range: 0 to 100%.
- c. Accuracy: $\pm 2.5\%$ RH between 50 and 104 DegF.
- d. Repeatability: 0.5% RH/year
- e. Sensitivity: 0.4%RH
- f. Hysteresis: Less than 1%.
- g. Stability: Better than 1.0% RH over a year. (Long term stability)
- h. Temperature effect: Temperature compensated with less than 0.06% per °F.
- i. Supply voltage: 18-38 VDC
- j. Output: Two-wire loop-powered, 4-20 ma, %0 to 100% linear
- k. Adjustments: One point with calibrator (duct mounted applications).
- l. Operating temperature: -40°F to 130°F
- m. Storage temperature: -85°F to 158°F
- n. Max load: (Supply voltage 10VDC)/0.02, 700Ohms@ 24VDC
- o. Connections screw terminals for loop terminations.
- p. Provide 2 years warranty.
- q. Sensor manufacturer shall send samples, mounting options and appearance to architect for approval prior to shipment.
- r. Manufacturer - Vaisala

2. Combination Temperature and Humidity Sensors

- a. The assembly shall consist of a temperature and humidity sensor mounted in a ventilated housing suitable for wall mounting.
- b. Coordinate Temperature Sensor faceplate requirements with architect/owner and engineer.
- c. Faceplates options shall include color, blank faceplate option, display faceplate option, setpoint adjustment option and occupied/unoccupied override option) Submit for approval.
- d. Humidity Sensor
 - 1) Sensor Humidity Operating Range: 0 to 100%.
 - 2) Accuracy: $\pm 2.5\%$ RH between 50 and 104 DegF.
 - 3) Repeatability: 0.5% RH/year
 - 4) Sensitivity: 0.4%RH
 - 5) Hysteresis: Less than 1%.
 - 6) Stability: Better than 1.0% RH over a year. (Long term stability)
 - 7) Temperature effect: Temperature compensated with less than 0.06% per °F.
- e. Temperature Sensor
 - 1) Sensor Operating Range: 20 DegF to 120 DegF
 - 2) Accuracy: ± 1 DegF.

- 3) Repeatability: 0.5% RH/year
 - 4) Sensitivity: 0.4%RH
 - 5) Hysteresis: Less than 1%.
 - 6) Stability: Better than 1.0% RH over a year. (Long term stability)
 - f. Output: Two - Two-wire loop-powered, 4-20 ma, %0 to 100% linear
 - g. Adjustments: One point with calibrator (duct mounted applications).
 - h. Operating temperature: -40°F to 130°F
 - i. Storage temperature: -85°F to 158°F
 - j. Max load: (Supply voltage 10VDC)/0.02, 700Ohms@ 24VDC
 - k. Connections screw terminals for loop terminations.
 - l. Provide 2 years warranty.
 - m. Manufacturer - Vaisala
3. Carbon Dioxide Sensor – Duct Mounted
- a. Provide duct mounted carbon dioxide infrared microprocessor based sensor.
 - b. Measurement range of 0 to 2000 PPM; accuracy +/-40 ppm (+/- 3% of reading)
 - c. Analog Output: 4-20mA or 0-10VDC and Modbus proportional output signal, temperature compensated Maximum drift of ± 100 PPM per year.
 - d. Relay Output: 1 DPDT contact 5A, 30 VDC or 250VAC, Alarm contacts to close when user defined setpoint is reached. Adjustable alarm limit of 0 to 2000 PPM, factory set at 1000 PPM of carbon dioxide.
 - e. Microprocessor based offset algorithm to automatically compensate for drift.
 - f. Maximum response time: < 60 sec.
 - g. Power requirements: 24VAC/VDC 200mA
 - h. Manufacturer / Model
 - 1) Vulcain / 90DM3A
4. Carbon Dioxide Sensor– Wall / Surface Mounted
- a. The carbon dioxide sensor shall provide an output signal correspondence linearly to 0-2000 ppm/0-5000 ppm (user adjustable) of CO₂ using Non-dispersive Infrared (NDIR) technology.
 - b. The CO₂ concentration shall be determined by measuring the attenuation of a specific wavelength of infrared light travels from its source to a detector along a defined optical path. The sensor shall detect the amount of attenuation and convert it into a 0 to 10 VDC analog output signal, which corresponds linearly to 0 to 2000 ppm sensed concentration of CO₂.
 - c. The sensor features shall have a membrane filter to help prevent contaminants from entering the sensing chamber and yet remain permeable to CO₂.
 - d. A microprocessor-based offset compensation algorithm shall automatically compensate for drift. The compensation algorithm shall include a self-test that can detect problems (such as excessive drift) and initiate an alarm signal.
 - e. In addition to compensating for drift, the microprocessor shall speed the full calibration process by automatically adjusting the span (of the 0 to 2000 ppm output range). One easy accessed button shall complete this process.
 - f. Provide a separate 24 VAC transformer and power and control wiring.

- g. The sensor shall be suitable for duct and space mounting as shown on the drawings. Provide carbon dioxide sensors as quantified in device schedule and shown mechanical drawings.
 - h. Sensor minimum requirements:
 - 1) Accuracy ± 30 ppm + 2 % of reading (at room conditions).
 - 2) Repeatability ± 10 ppm CO₂
 - 3) Maximum Drift ± 50 ppm CO₂ per year
 - 4) Output Signal 0 to 10 VDC/4-20 mA proportional over the 0 to 2000 ppm/0-5000ppm CO₂ range
 - i. Alarm Relay: SPST normally open dry rated for 10W maximum, 100 or 500 mA DC maximum with adjustable limit (0-2000 CO₂ factory set at 1000ppm ± 50 ppm CO₂)
 - j. Alarm Set Resolution ± 20 ppm CO₂ minimum
 - k. Alarm Hysteresis 50ppm CO₂
 - l. Calibration Adjustments Automatic zero compensation and span calibrations; uses calibrated span and zero.
 - m. Calibration interval – greater than two (2) years
 - n. Adjustment Resolution 20ppm CO₂ minimum
 - o. Response Time: <30 seconds to 63 percent of step change, <60 seconds to 100 percent of step change
 - p. Warm up time: 5 minutes
 - q. Ambient Operating Conditions 32 to 122°F
 - r. 5 to 95 percent RH, non-condensing
 - s. Provide a calibration kit (flow system type) including zero gas and test carbon dioxide gas. Turn over complete kit to owner at warranty start date
 - t. Provide weatherproof enclosure for outdoor air mounting
 - u. Manufacturer / Model
 - 1) Vaisala / GMW90.
5. Gas Detection System – Garage CO & NO₂
- a. Gas detection system shall be designed to alarm and initiate ventilation via the BMS upon the presence of Carbon Monoxide (CO) and Nitrous Oxide (NO₂) generated by the operation of vehicles within the garage, loading dock areas and similar spaces. The system shall consist of the following:
 - b. Controller
 - 1) Controller shall be a microprocessor based system, complete with power supplies, input and output modules, real time clock, memory, processors and all other items necessary for proper and correct interfacing with the gas monitoring system devices, operation of the control functions as described in the sequence of operations and the BACnet network communications capabilities as required by the BACnet building management system (BMS). The BACnet communication feature shall allow the BMS the capability of remote monitoring of the sensors as well as the status of the system.
 - 2) The controller shall be provided with additional expansion I/O modules as required capable of accepting binary, analog, and providing binary and analog outputs. The controller shall be modular and be capable of future field upgrades to include additional modules and sensors.

- 3) The system controller shall be capable of communicating digitally with networked gas sensors and annunciator assemblies through three RS485 communication busses. Each bus shall be capable of accepting 32 devices including sensors, relay modules, annunciator panels, and horn/strobe modules.
- 4) Each controller shall have an indicator which shows each sensors gas value as it sequences through the sensors. It shall immediately terminate the sequence and display any sensor in alarm and its location. The panel shall have a minimum 65 dB audible alarm and a silence switch. The panel will have a real time clock and shall be capable of timed operation of external devices such as fans should the application warrant it.
- 5) The controller shall operate from a 120VAC/24VAC low voltage supply as provided by the manufacturer.
- 6) The controller(s) shall be wall mounted in NEMA 4X enclosures.
- c. Central Control Panel shall meet the following requirements:
 - 1) Each channel shall have 3 concentration levels and a fault alarm.
 - 2) Internal battery backup for complete operation of system for up to ½ hour of power loss.
 - 3) Digital display of concentration and alarm condition
 - 4) Event data logger
 - 5) Manual reset pushbutton
- d. Sensors
 - 1) CO and NO2 sensors shall be of the electrochemical type. Each sensor shall be addressable over the RS485 bus. Each sensor shall include a local DPDT relay. All sensors shall be installed per manufacturer's recommended installation. Sensors shall have a minimum radius of coverage of 50ft.
 - 2) Sensors shall be powered by low voltage as provided by the system controller.
 - 3) Sensors shall operate and report to the controller continuously. Sample draw type systems shall not be permitted.
 - 4) Gas sensor shall meet the following requirements
 - a) Loop powered
 - b) Local Display and keypad.(model dependent)
 - c) Display concentration, output and fault condition
 - d) NEMA 4x Enclosure.
 - e) Automatic Temperature Compensation
- e. Warning /Activation Assemblies
 - 1) Warning /activation assemblies shall be provided and located by the main exits.
 - 2) The assemblies shall be comprised of a beacon, strobe and pushbutton/reset pull station.
- f. Startup service shall be provided by a factory trained technician
- g. Test and Calibration Equipment

- 1) All necessary calibration and testing equipment shall be provided to perform the testing, commissioning and acceptance testing as part of the deliverable.
 - h. Test and Calibration Equipment
 - i. All necessary calibration and testing equipment shall be provided to perform the testing, commissioning and acceptance testing as part of the deliverable
 - j. Manufacturer:
 - 1) Sensidyne
 - 2) MSA
 - 3) Or Approved Equal.
6. Carbon Monoxide Detection System
 - a. Provide a UL listed gas semiconductor or electrochemical sensors in an enclosure suitable for loading dock applications networked to a gas detection controller.
 - b. BMS Contractor to provide wiring, conduit, relays, etc., for a complete system.
 - c. Controller
 - 1) Fully programmable with up to 2 levels of alarm plus system fault relay to initiate the area exhaust fans and notification devices
 - 2) Controller shall be Modbus or BACnet compatible with capability to manage the total number of sensors required or a maximum of 96 transmitter inputs
 - 3) Back lit Alphanumeric or LED display
 - 4) Relay Outputs: a minimum of 4 DPDT contacts 5A, 30 VDC or 250VAC rated, shall be supplied in order to notify alarm status to the BMS
 - 5) Audible Output: minimum 65dBA Alarm with local reset button
 - 6) Enclosure shall be designed for use in NEMA 4X installations
 - 7) Controller shall be design to communicate with a network of sensors (RS-485 Modbus) and include the capability to provide digital communication output of BACnet or Modbus.
 - d. Warning /Activation Assemblies
 - 1) Warning /activation assemblies shall be provided and located by the main exits.
 - 2) The assemblies shall be comprised of a beacon, strobe and pushbutton/reset pull station.
 - e. Manufacturer:
 - 1) Sensidyne
 - 2) MSA
7. Current Transducers - Analog Output
 - a. Provide and install split core current sensors to interface with the DDC system as described in Sequence of Operations and as shown on Control Drawings.
 - b. Units shall be UL listed.
 - c. Each sensor shall be two wire, loop powered and sized for expected amperage.
 - d. Analog Output Current Transducer
 - e. Typical installations used for the determination of current consumption of fan and pump motor in remote starter enclosures.

- f. Power requirements: Self powered, 0-60 Amp rating
 - g. Output: 0-5 VDC
 - h. Accuracy +/-2.0% Full scale
 - i. Manufacturer: Veris - Hawkeye H922
- 8. Current Transducers - Analog Output - Variable Frequency Drive Applications
 - a. Typical installations used for the determination of VFD driven fan and pump motor status points in remote starter enclosures.
 - b. Self-adjusting setpoint, automatic compensation for effects of frequency and amperage changes related to VFD (insensitive to frequencies 10-80 hz)
 - c. Current sensor shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.
 - d. Power requirements: Self powered induced from line
 - e. Accurate to 0.5% full scale
 - f. Output: 4-20mA
 - g. Manufacturer: Veris - Hawkeye H720
- 9. Digital Output Current Switch
 - a. Typical installations used for the determination of fan and pump motor status points in remote starter enclosures.
 - b. Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.
 - c. Power requirements: Self powered induced from line
 - d. Adjustable setpoint 2.5-135A
 - e. Output: One normally open contact; 1 A rating at 30VAC/VDC
 - f. Manufacturer: Veris - Hawkeye H908
- 10. Digital Output Current Switch (Variable Frequency Drive Applications)
 - a. Typical installations used for the determination of VFD driven fan and pump motor status points in remote starter enclosures.
 - b. Self-adjusting setpoint, automatic compensation for effects of frequency and amperage changes related to VFD
 - c. Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.
 - d. Power requirements: Self powered induced from line
 - e. Output: One normally open contact; 0.1 A rating at 30VAC/VDC
 - f. Manufacturer: Veris - Hawkeye H904
- 11. Digital Output Current Switch (Electronically Commutated Motor (ECM) Applications)
 - a. Typical installations used for the determination of ECM controlled fan and pump motor status points in remote starter enclosures.
 - b. Adjustable minimum turn-on to prevent false trip due to ECM stand-by current
 - c. Current sensing switches shall be split core.
 - d. Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.
 - e. Power requirements: Self powered induced from line

- f. Output: One normally open contact; 1.0 A rating at 30VAC/VDC
 - g. Manufacturer: Senva C-2320-L-ECM
- 12. Occupancy Sensors
 - a. Occupancy sensors shall be provided to interface with the DDC system as described in Sequence of Operations.
 - b. Occupancy Switch can be combined with space temperature sensor. Sensor shall use either passive infrared or ultrasonic technology with sensitivity adjustment
 - c. Power requirements: 24 VDC
 - d. Output: 2 Form C contacts; 1 A rating at 24VDC
 - e. Manufacturer:
- 13. Water Leak Detection Sensors - Point
 - a. Water leak detection sensors shall be provided to interface with the DDC system as shown on Control Drawings.
 - b. Sensors: Shall be comprised of two gold-plated sensing probes for corrosion resistance and microchip technology for dependable and accurate detection of conductive liquids. Supervised operation—signals on leak detected, circuit failure or power loss
 - c. Power requirements: 24 VAC/VDC, 100mA, 50/60Hz, 3 VA (max)
 - d. NEMA 1 Enclosure
 - e. Output: 2 Form C contacts; 3 A rating at 24VAC
 - f. Manufacturer: Emerson, Liqui-tect
- 14. Water Leak Detection System - Areas
 - a. Provide advanced system water leak detection system for detecting water in individual area and area floor drain as reflected in drawings.
 - b. The liquid sensing cable shall detect the presence of water and other conductive liquids. The cable shall consist of four wires: two wires serve as liquid sensors and two other wires serve as continuity and alarm signal links. All four wires shall be helically wound around a central core (function as carrier) and away from the surface area of this core (to protect the four wires physically). The cable shall be made of material which is non-flame propagating and self-extinguishing.
 - c. The sensing cables shall be of such construction that no metallic parts shall be exposed to the environment. The system shall be provided with the flexibility of custom "cut-to-length" sensing cable to meet the exact length requirement at each AHU gallery and with pre-connectors sensing cable components. The cable shall be UL listed and FM approved.
 - d. Provide all mounting clips and accessories for a complete system.
 - e. Sensing cable in each area shall be connected to its independent detection system via leader cable. System shall consist of a main control panel and interface modules. Each main panel system (mounted on wall) shall provide a dry contact upon detection of water in floor drain to BMS. Each main panel system shall be capable of monitoring up to 5000 ft of sensing cable.
 - f. Main Panel:
 - 1) Summary relay contacts, LED status lights, LCD information display at the panel.
 - 2) Standard external interface modes include:

- a) dry contacts
 - b) BACnet MSTP communication.
 - 3) Event history accessible from the front panel or via serial port to identify type of event, time, location, and other parameters for all sensor events or user adjustments and interventions.
 - 4) Layered password protection for setup changes.
 - 5) Adjustable sensitivity and selectable measurement units.
 - 6) Universal power supply for 120/240 Vac 50/60 Hz.
 - 7) Non-volatile memory for event history, setup and network configuration.
 - 8) Precision to locate leak: $\pm 0.5\%$ maximum of circuit length.
 - g. Interface / Auxiliary Module:
 - 1) Monitor up to 500 feet (150 meters) of sensing cable.
 - 2) Precision: 0.5% of sensor length ± 2 ft (0.6m).
 - 3) Voltage-free contact for alarm signaling.
 - 4) LED indicators.
 - 5) Serial connection between modules and main panel up to 4000 feet without amplification.
 - 6) Power supplied by Main panel.
 - 7) Provide with NEMA 4 enclosure.
 - h. Leak detection system panel shall be able to operate between within 32 deg F (0 deg C) to 122 deg F (50 deg C) and 5 to 95% RH. Provide laminated or framed (glass or plastic protective cover) leak detection identification map indicating the leak detection system layout with reference points. Install a map in each associated area.
 - i. Approved Manufacturers
 - 1) Trace Tek (Raychem)
 - 2) ELSA
 - 3) Liebert
 - 4) Pentair
 - 5) Approved equal
 - 15. Window Position Switches
 - a. Provide and install window switches according to design drawings and manufacturer installation requirements.
 - b. Coordinated installation with Architect
 - c. Get written approval of final selection and installation method of devices with architect
 - d. Manufacturer - Sentrol
 - e. Model- Guardswitch Series 100
 - 16. Door Switches
 - a. Provide and install door switches according to design drawings and manufacturer installation requirements.
 - b. Coordinated installation with Architect
 - c. Get written approval of final selection and installation method of devices with architect
 - d. Manufacturer - United Security
 - e. Model- SP3000A
- G. Automatic Control Valves

1. Control valves assemblies shall be provided and delivered from a single manufacturer as a complete assembly.
2. The manufacturer shall warrant all components for a period of 5 years from the date of production with the first two years unconditional.
3. Characterized Control Valves - Modulating
 - a. Control valves shall be globe or characterized ball valves.
 - b. A TEFZEL flow-characterizing disc shall be installed in the inlet of two-way characterized control valves and in the control port of three-way valves. The valve trim shall utilize a stainless steel ball and stem for all water or glycol solutions up to 60%. For water applications, an optional chrome plated brass ball and brass stem may be used for sizes ¾" and smaller.
 - c. Valve bodies shall be nickel-plated, forged brass with female NPT threads. Bodies to 1 ¼" shall be rated at 600 psi and sizes 1 ½" to 3" at 400 psi.
 - d. Characterized Control Valves shall have a self-aligning, blowout proof, brass stem with a dual EPDM O-ring packing design. Fiberglass reinforced Teflon seats shall be used.
 - e. The valves shall have a four bolt mounting flange to provide a 4 position, field changeable, electronic actuator mounting arrangement.
 - f. A non-metallic coupling, constructed of high temperature, continual use material shall provide a direct, mechanical connection between the valve body and actuator. The coupling shall be designed to provide thermal isolation and eliminate lateral and rotational stem forces. Vent hole shall be provided to reduce condensation build-up.
4. Two Position Control Valves
 - a. Control valves shall be globe or ball valves.
 - b. Line size full ported valves shall be used to minimize pressure drop.
 - c. The valve trim shall utilize a stainless steel ball and stem for all water or glycol solutions up to 60%. For water applications, an optional chrome plated brass ball and brass stem may be used for sizes ¾" and smaller.
 - d. Valve bodies shall be nickel-plated, forged brass with female NPT threads. Bodies to 1 ¼" shall be rated at 600 psi and sizes 1 ½" to 3" at 400 psi.
 - e. Valves shall have a self-aligning, blowout proof, brass stem with a dual EPDM O-ring packing design. Fiberglass reinforced Teflon seats shall be used.
 - f. The valves shall have a four bolt mounting flange to provide a 4 position, field changeable, electronic actuator mounting arrangement.
 - g. A non-metallic coupling, constructed of high temperature, continual use material shall provide a direct, mechanical connection between the valve body and actuator. The coupling shall be designed to provide thermal isolation and eliminate lateral and rotational stem forces. Vent hole shall be provided to reduce condensation build-up.
5. Valve Actuators:
 - a. Valve actuators shall be electric, and properly selected for the valve body and service. Actuators shall be fully proportioning and be fail in place, spring return for fail open or fail closed operation as specified. Floating control actuators shall not be acceptable.
 - b. The controls contractor shall provide control power transformers for valve actuators for low voltage operation as required.

- c. If upon contractor's final sizing of valve and actuators it has been determined that the power required for the assembly exceeds the power available from the BMS control panel, the contractor shall coordinate with the Div. 26 contractor for additional power.
 - d. Manufacturer:
 - 1) Belimo
- 6. Thermostatic radiator valve
 - a. Assembly shall be selected to maintain room temperature within $\pm 1^{\circ}\text{F}$.
 - b. The operator shall be of a bellows design with a vapor or liquid charge and shall be connected to the valve via a snap-on fast mounting system or secured by an Allen screw.
 - c. The thermostatic operator shall be capable of temperature adjustment between 45° and 86°F (7 and 30°C) and be locked and limited by the use of limiting pins or internal mechanism.
 - d. The valve shall be of nickel plated brass construction with a fully replaceable packing gland capable of replacement while the system is in operation. The valve disc shall be constructed of EPDM, capable of withstanding 250°F (121°C).
 - e. Provide a separate remote wall mounted dial and remote sensor (as applicable).
 - f. The thermostatic radiator valve and accessories shall be Danfoss or an approved equal.

H. Dampers

- 1. Motorized Control Dampers
 - a. Motorized Control Dampers shall have 13 gauge galvanized frames of not less than 3" in width and blades of 16 gauge, or double 22 gauge, galvanized steel and shall be adequately braced to from a rigid assembly where required in galvanized ductwork. Dampers shall have blades not more 8" wide. Linkage and hardware shall be zinc plated steel. Damper blades and rods shall be installed in horizontal position.
 - b. All dampers shall be of the opposed blade type, and shall be electric motor operated. Dampers shall have continuous elastomer or stainless steel stops to avoid leakage. Bearings shall be oil tight non-ferrous sleeve type. All dampers shall be provided with continuous $3/16"$ x $1/2"$ closed cell neoprene gasketing around perimeter of the frame and at interlocking blade edges to form an airtight seal.
 - c. All dampers shall be constructed to provide a maximum leakage in accordance with ASHRAE/IES 90.1 and tested to ANSI /AMCA Std 500. Submit leakage and flow characteristic data for all dampers.
 - d. All outside air dampers shall automatically close in the event of a loss of power, unless otherwise noted.
 - e. Outdoor air applications in costal environments shall be provided with TAMCO SW (saltwater), Ruskin CE or approved equal, construction features
 - f. Dampers shall be Imperial, Ruskin or approved equal.
- 2. Damper Operators:
 - a. Damper operators shall be electric, spring return or fail in place, and shall be properly sized so as to stroke the damper smoothly and efficiently

- throughout its range. Actuator response shall be linear in response to sensed load.
- b. The controls contractor shall provide control power transformers for damper actuators for low voltage operation as required.
3. Damper End Switches
 - a. Damper end switches shall comprise of high temperature micro switches, mercury switches are not acceptable.
 - b. Damper end switch shall comprise of one switch which closes when the blades are fully open and the second switch closes when the blades are fully closed
 - c. Damper end switches shall be provided for each actuator controlled damper section. If more than one end switch is provided for a damper assembly, the wiring of damper section end switches in parallel is acceptable.
 - d. Manufacturer: Ruskin
- I. Electrical metering devices
 1. Division 26 shall provide electrical meters which shall provide inputs to the BMS via a Modbus or BACNET communications protocol. Refer to Division 26 specifications for additional details as to the data being monitored. The interface shall allow for full monitoring of the device encompassing multiple inputs to the BMS.
 - J. Field Equipment Cabinets:
 1. All indoor control cabinets shall be fully enclosed NEMA 1 (minimum, see NEMA rating for enclosures within this specification) construction with (hinged door) key-lock latch and removable sub panels. A single key shall be common to all field panels and sub panels. All transformers, electric relays, manual override switches, etc., shall be mounted within the enclosure and factory wired to terminal strips.
 2. Interconnections between internal and face mounted devices shall be prewired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600 volt service (or in accordance with line voltage), individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
 3. Provide ON/OFF power switch with overcurrent protection for control power sources to each local panel.
 4. Provide 6" x 6"trough the width of the control panel, minimum 24" in length, above the control panel to provide an entrance for cabling and tubing into the panel, with 50% spare nipple capacity.
 5. Panels shall be located to avoid conflicts with ductwork, piping, equipment, the work of other trades, and building conditions. Panel locations indicated on the Drawings shall be coordinated prior to installation and adjusted to avoid conflicts.
 - K. Test and Calibration Equipment

1. All necessary calibration and testing equipment shall be provided to perform the testing, commissioning and acceptance testing as part of the deliverable.
- L. Component Tags
 1. Valve Tags:
 - a. All automatic and manual valves provided by this contractor, shall be identified with 2" diameter brass tags and brass chains. Lettering shall be 1/2" high, stamped and painted black. Automatic valve tags shall be stamped with the letters "AV" and sequentially numbered. Provide valve schedule and sample tags for approval.
 2. Sensor Tags:
 - a. All sensors/instruments shall be identified with 1"x 3" black lamacoid labels with engraved white lettering. Lettering shall be 1/4" high. Provide sensor number, Air handling unit number/pump/source equipment (as relevant), part number and sensor range on tag.

PART 3 - EXECUTION

3.1 Building MANAGEMENT SYSTEM - GENERAL

- A. Space mounted devices are to be identical in appearance. All devices shall be mounted under the same style cover.
- B. Provide all relays, switches, sources of electricity and all other auxiliaries, accessories and connections necessary to make a complete operable system in accordance with the sequences specified.
- C. Install controls so that adjustments and calibrations can be readily made.
- D. Mount surface-mounted control devices on brackets to clear the final finished surface on insulation.
- E. Conceal control conduit and wiring in all spaces except in the Mechanical Equipment Rooms and in unfinished spaces. Install control conduit and wiring in parallel banks with all changes in directions made at 90 degree angles.
- F. Install control valves horizontally with the power unit up. Installation of control valves will be by the Division 23 Contractor.
- G. Unless otherwise noted, install wall mounted sensors, thermostats and humidistats at 5'-0" above the finished floor measured to the centerline of the instrument. Submit device locations, mounting heights and details for approval.
- H. Install outdoor thermostats in perforated tube and sun shield or engineer approved installation assembly designed for application.

3.2 PNEUMATIC TUBING & INSTALLATION

- A. Concealed spaces: Pneumatic tubing shall be polyethylene tubing.
- B. Exposed: Where pneumatic tubing is installed in exposed areas susceptible to damage (i.e., located outdoors, exposed to heavy pedestrian or maintenance traffic), tubing shall be polyethylene tubing installed in conduit.
- C. Splicing of pneumatic tubing is not acceptable.

3.3 SENSOR TUBING & INSTALLATION

- A. Concealed spaces: Tubing shall be copper tubing.
- B. Exposed: Where tubing is installed in exposed areas susceptible to damage (i.e., located outdoors, exposed to heavy pedestrian or maintenance traffic), tubing shall be installed in conduit.

3.4 ELECTRICAL INSTALLATION

- A. General
 - 1. For conduit support and installation of wires and cables see applicable paragraphs of the latest edition of the NEC.
- B. Raceways and Conduit
 - 1. All conduit/cable entry to control panels shall be from the bottom or sides to prevent condensation from draining into electronic equipment contained within.
 - 2. Conduit / EMT percent fill shall not exceed maximum NEC allowable fill.
 - 3. Use liquid tight flexible metal conduit for making connections at instruments and devices mounted on piping or vessels or on equipment subject to vibration.
- C. Wiring
 - 1. Line voltage wiring, concealed or exposed, shall be installed in accordance with Division 26, local electrical code and the NEC.
 - 2. Low voltage data transmission wiring, except the primary peer-to-peer communications trunk,
 - a. installed in concealed, accessible areas shall be plenum rated cable
 - b. installed in concealed, non-accessible areas shall be installed in EMT(metal).
 - c. installed in exposed areas, such as mechanical equipment rooms, shall be installed in EMT(metal).
 - 3. Peer-to-peer communications including trunk low voltage data transmission and wiring between controllers shall be installed in EMT(metal).
 - 4. Cables for 120/24 VAC wiring and low level signal wiring shall always be run in separate raceways.
 - 5. Wire splices within conduit are prohibited under any circumstances.

6. All smoke control wiring including Fire Alarm System Relay and Monitoring Modules shall be in accordance with Division 26.
 7. All wiring shall be in accordance with this specification and Division 26, including tagging, labeling and identification.
 8. Controllers shall be provided with an independent terminal strip for field wiring. All control wiring internal to the panel landing direct on I/O will be done through a terminal strip. Under no circumstances will field wiring be terminated from inputs or outputs direct to the I/O controllers.
- D. Contractors' tests shall be scheduled and documented in accordance with the commissioning requirements.

3.5 SEQUENCE OF OPERATIONS

A. Initial Space Setpoints – Unless otherwise noted in Sequence of Operations.

	COOLING		HEATING	
Room Type	Temperature Setpoint (Cooling) Deg F		Temperature Setpoint (Heating) Deg F	
	Occupied	Vacancy Setback (if applicable)	Occupied	Vacancy Setback (if applicable)
Garages	N/A	N/A	60	N/A
MEP	75	80	68	60
Closets/Storage Rooms	75	80	68	60
Health Club/waiting room	72	80	68	60
Conference/meeting rooms	72	80	68	60
Office Spaces	72	80	68	60
Corridors	75	80	68	60
Locker/Dressing Rooms	75	80	68	60
Dormitory/Sleeping Areas	72	80	68	60

B. ASP and Slab Heating Radiant System

1. General:

- a. The Heating Hot Water System is comprised of a modular ASHP, capable of providing heating hot water (HHW) to the slab. The system is arranged in a variable primary / variable secondary system.
- b. The ASHP system shall be provided with a master controller capable of staging the heat pump modules and the production of the HHW at setpoint. The BMS shall enable/disable the ASHP based on the required operation.
- c. The system shall monitor space temperatures.

- d. The system shall include both BMS and OEM Slab Temperature Controller (Tekmar or equal) to provide the functions depicted on the mechanical and control design drawings.
 - e. The OEM controller shall be integrated to the BMS, contractor to coordinate with approved submittals and provide all necessary hardware, and programming to integrate.
 - 2. System Equipment
 - a. Packaged 2 pipe Air Source Heat Pump modular system with OEM master controller and two modules.
 - b. HHW Pump 1, Duty, ECM, 0% speed output - ASHP.
 - c. HHW Pump 2, Duty, ECM, 0% speed output - Slab.
 - d. 3 Way Blending Temperature Control valve, modulating type, fail in place, normally open to HHW recirculation.
 - 3. System off:
 - a. When the system is off all valves, pumps, and control devices shall be in their normal positions.
 - 4. System on:
 - a. The system shall be started based on a call for space heating or manually via the BMS.
 - b. Once the system is started, the BMS shall
 - 1) Start HHWP 1 and ramp pump to minimum speed
 - 2) Start HHWP 2 and ramp pump to minimum speed
 - 3) Send an enable signal to the ASHP.
 - c. Once complete the BMS shall initiate HHW differential pressure, flow and temperature control sequences.
 - 5. HHW Differential Pressure Control - ASHP HHW
 - a. The HHWP 1 shall ramp up to speed and modulate to meet the ASHP water differential pressure setpoint (adj.). DP setpoint to be coordinated with the ASHP approved submittal manufacturer specific requirements, initially set to 2 psi(adj.).
 - 6. HHW Flow Control - Slab
 - a. The HHWP 2 shall ramp up to speed setpoint, setpoint to be coordinated with testing and balancing contractor.
 - 7. HHW Temperature Control - Space Temperature
 - a. The BMS shall upon proof of HHWP 2 flow, modulate the three way temperature control blending valve to meet the HHW supply temperature as measured upstream of the slab manifolds. The HHW setpoint shall be set initially to 100.
 - 8. Alarms
 - a. Space temperature is below 50 DegF (Adj.)
 - b. The system pressure monitored at expansion tank shall be monitored by the BMS. On indication of a low or high pressure condition 10% deviation from setpoint an alarm will be generated on the bms workstation.
 - c. The BMS shall monitor the ASHP common alarm.
 - d. The BMS shall monitor the Glycol Feeder common alarm.
- C. DX Packaged Air Handling Unit (DOAS-X) (OEM Controller)
 - 1. General
 - a. Packaged unit, normally off.
 - b. System shall be controlled via manufacturer provided controller.

- c. BMS shall integrate to controller via BACnet or Modbus, final protocol to be determined based on approved shop drawings.
 - 2. System Off
 - a. When the system is off, all devices shall be in their normal position as stated above.
 - 3. System Start Up
 - a. The system shall be enabled via the BMS based on a time of day schedule or manual command from the BMS workstation.
 - b. Whenever the system is called to run, a request to run signal (unique to system) shall be sent to the FAS. the FAS shall then command all associated FSD'S to their open position.
 - c. The manufacturer provided controller shall operate the unit to meet the supply air temperature setpoints (adj – provided via the BMS) and humidity setpoints (adj – provided via the BMS) and supply and exhaust duct static pressure (adj – determined during testing and balancing).
 - d. The manufacturer provided controller shall include programming for fire alarm system request to run, morning warmup, and morning cooldown modes.
 - 4. Alarms
 - a. The BMS shall monitor the unit status and common alarms, in addition to any alarms provided via integration.
- D. Energy Recovery Ventilator (ERV-X) (OEM Controller)
 - 1. General
 - a. Packaged unit, normally off.
 - b. System shall be controlled via manufacturer provided controller.
 - c. BMS shall start and stop the ERV via hardwired control to the OEM controller.
 - 2. System Off
 - a. When the system is off, all devices shall be in their normal position as stated above.
 - 3. System Start Up
 - a. The system shall be enabled via the BMS, based on a time of day schedule or manual command from the BMS workstation.
 - b. The manufacturer provided controller shall operate the unit to meet the supply and return constant air flow control.
 - 4. Alarm
 - a. Status mismatch –
 - 1) Fan is commanded on and the fan status is off as determined by the current sensor.
- E. VRF FCU SERVING BOH SPACES TYPICAL
 - 1. The system shall be controlled via manufacturer provided thermostats, occupancy sensor (As Applicable), gas detection, leak sensor and controllers furnished with the unit.
 - 2. BMS integration:
 - a. The unit controller shall be integrated with the BMS
 - b. The following points shall be provided with direct control from the BMS over the integration
 - 1) System enable
 - 2) Cooling setpoint and setback

- 3) Heating setpoint and setback (If applicable)
- c. The BMS shall be programmed for occupied and unoccupied time determination of the spaces served. The schedule is to be initially set for the following;
 - 1) Occupied - Monday through Friday (6am to 6-pm)
 - 2) Unoccupied - at all other times.
- d. Temperature setpoints are to be as follows;
 - 1) Scheduled Occupied cooling: 75 °F(adj.)
 - 2) As- Applicable - Standby cooling: 77 °F(adj.) (Occupancy Sensor Based)
 - 3) Scheduled Unoccupied cooling: 80°F(adj.)
 - 4) Scheduled Occupied heating: 70 °F(adj.) (If applicable)
 - 5) As- Applicable - Standby heating: 67 °F(adj.) (Occupancy Sensor Based)
 - 6) Scheduled Unoccupied heating: 60 °F(adj.) (If applicable)
- e. Temperature control:
 - 1) On a call for cooling, the manufacturer's controller shall begin to modulate fan speed and refrigerant flow to the DX coil unit in order to control to the cooling setpoint.
 - 2) On a call for heating, the manufacturer's controller shall begin to modulate fan speed and refrigerant flow to the DX coil unit in order to control to the heating setpoint. (If applicable)
 - 3) The mfr controller shall automatically energize the outdoor condensing unit to accommodate the temperature control requirements.
- 3. The BMS shall be monitor space temperature via space thermostat
- 4. The zone shall be monitored by OEM provided occupancy sensors (As- Applicable - refer to mechanical plans for applicability). The zone shall be indexed to the standby setpoint during scheduled occupied mode if occupancy is not detected for a period of 30 minutes (adjustable).
- 5. The BMS shall be monitor space temperature via space thermostat
- 6. Each unit shall be equipped with a high-level water sensor in the condensate pan Leak detection shall be provided by the manufacturer. If the sensor is tripped the unit shall automatically shut down.
- 7. Additional monitoring and alarms:
 - a. Normal Alarms:
 - 1) Space temperature is {5°F} lower than the setpoint for {15 consecutive minutes}.
 - 2) Space temperature is {5°F} higher than the setpoint for {15 consecutive minutes}.

F. VAV AND EVAV SERVING VRF TYPICAL

- 1. For operation of VRF refer to VRF FCU SERVING BOH SPACES TYPICAL sequence.
- 2. VAV - Exhaust VAV With VAV Flow Offset
 - a. SUMMARY
 - 1) Variable air volume (EVAV), modulating type, fail last position.
 - 2) The VAV consists of an exhaust air volume damper and pressure pick-up probes for airflow measurement.

- b. The local VAV controller shall control the airflow to each CAV terminal box. Each terminal box shall be programmed for a design flow setpoint as measured by a flow sensor.
 - c. Provide a time of day schedule for each CAV. Initially set each schedule for Occupied during building business hours and Unoccupied at all other times and coordinate with VRF schedule.
 - d. The terminal box flow shall be indexed to the unoccupied flow setpoint during unoccupied hours in accordance with the mechanical schedule.
 - e. The terminal box flow shall be indexed to the occupied flow setpoint during occupied hours in accordance with the mechanical schedule.
 - f. Demand Control Ventilation – Applicable to zones with CO2 Sensors
 - 1) During Occupied mode, BMS will generate Demand Control ventilation signal based on current zone CO2 level and zone CO2 setpoint. Zone CO2 setpoint will be equal to 600 PPM plus the outdoor air CO2 concentration.
 - 2) As DCV control signal increases from 0% to 100%, BMS will reset active zone minimum supply air CFM limit from scheduled minimum to scheduled maximum CFM.
 - g. ALARMS
 - 1) Space CO2 level, if monitored, is higher than {1000 PPM} for {15 consecutive minutes}.
 - 2) Supply Air temperature is {5°F} lower than the setpoint for {10 consecutive minutes}.
 - 3) Supply Air CFM is {10%} higher than the setpoint for {15 consecutive minutes}.
 - 4) Supply Air CFM is {10%} lower than the setpoint for {15 consecutive minutes}.
3. EVAV - Exhaust VAV With VAV Flow Offset
- a. SUMMARY
 - 1) Exhaust variable air volume (EVAV), modulating type, fail last position.
 - 2) The EVAV consists of an exhaust air volume damper and pressure pick-up probes for airflow measurement.
 - b. OPERATION
 - 1) BMS shall modulate the airflow from each EVAV. Each EVAV shall be programmed for design flow setpoint as measured by a flow sensor.
 - 2) The EVAV operating schedule is to be coordinated with the VAV serving the space.
 - 3) When the VAV is in operation, the EVAV box shall index to the VAV airflow minus a scheduled offset. Offset shall initially be set to 50CFM (adj.) Final value to be coordinated with TAB contractor to provide slight negative pressurization to the space.
 - 4) When the VAV is closed, the exhaust VAV box shall be closed.
 - c. ALARMS
 - 1) Exhaust Air CFM is {10%} higher than the setpoint for {15 consecutive minutes}.
 - 2) Exhaust Air CFM is {10%} lower than the setpoint for {15 consecutive minutes}.

G. VAV and EVAV serving VRF, And Window/Door Switches Typical

1. For operation of system see VRF FCU SERVING BOH SPACES and VAV AND EVAV SERVING VRF sequence.
2. Window and door switches have been provided as noted on design drawings. Upon window or door switch proving open the associated VRF serving the space shall be disabled. VRF to be reenabled upon space temperature falls below low temperature setpoint, initially set to 50 Deg F (adj.).
3. Alarm
 - 1) Space air temperature is at low temperature setpoint for {5 consecutive minutes}.

H. Exhaust Fan (Starter) – EF-01

1. This sequence of operations applies to each of the following exhaust fans:
 - a. EF-01
2. General
 - a. Exhaust Fan, constant speed, off.
 - b. Exhaust air isolation damper, two position type, normally closed, fail closed (Only if damp applicable)
3. System Off:
 - a. When the system is off, the exhaust fan and damper shall be in the normal position as stated above.
4. System On:
 - a. Exhaust fan shall be started based on a time-schedule program resident in the BMS, or manually by an operator. The time-schedule program shall be adjustable at the operator workstation. Time schedule shall be as coordinated with the owner.
 - b. When the exhaust fan is enabled, its exhaust air isolation damper shall open. Once the damper proves open, the fan shall be permitted to start.
 - c. Exhaust fan shall operate at a constant speed.
5. Fan status shall be monitored at the BMS via a current sensor.
6. Maintenance alarms are generated at the operator workstation when:
 - a. Fan Status mismatch – Fan is commanded on and the fan status is off as determined by the current sensor
 - b. Damper Mismatch (isolation dampers):
 - 1) Position feedback and damper command disagree for more than 120 seconds (adj).

I. Diesel Exhaust Extraction System (Exhaust Fan (Starter) – EF-02

1. This sequence of operations applies to each of the following exhaust fans:
 - a. EF-02
2. General
 - a. Exhaust Fan, constant speed, off.
 - b. Exhaust air isolation damper, two position type, normally closed, fail closed (If applicable)
3. System Off:
 - a. When the system is off, the exhaust fan and damper shall be in the normal position as stated above.
4. System On:
 - a. Exhaust fan shall be started by an OEM controller/starter serving the vehicle exhaust extraction system.

- b. Exhaust fan shall operate at a constant speed.
 - 5. Fan status shall be monitored at the BMS via a current sensor.
 - 6. Maintenance alarms are generated at the operator workstation when:
 - a. Fan Status mismatch – Fan is commanded on and the fan status is off as determined by the current sensor
 - b. Damper Mismatch (isolation dampers):
 - 1) Position feedback and damper command disagree for more than 120 seconds (adj).
- J. Motorized Modulating Dampers
 - 1. Motorized modulating dampers shall be controlled by the BMS.
 - 2. Damper position shall be monitored by the BMS.
 - 3. Alarms & Additional Monitoring:
 - a. Damper Position Deviation:
 - 1) Difference between damper command and position feedback deviates beyond $\pm 10\%$ (adj) for 10 minutes (Adj)
 - 2) Generate Alarm to BMS
- K. Motorized Isolation Dampers
 - 1. Motorized isolation dampers shall be controlled by the BMS.
 - 2. Damper end switches shall be monitored by the BMS.
 - 3. Alarms & Additional Monitoring:
 - 1) Damper Mismatch (isolation dampers):
 - a) Position feedback and damper command disagree for more than 120 seconds (adj).
 - b) Generate Alarm to BMS
- L. Kitchen System
 - 1. For operation of system see VRF FCU SERVING BOH SPACES and VAV AND EVAV SERVING VRF sequence.
 - 2. Space includes a kitchen exhaust hood.
 - 3. The BMS shall monitor operation of kitchen exhaust hood via a current switch. Upon the hood proving operational via the current sensor status the VAV shall be ramped to 600 cfm (Adj.) and the EVAV shall be closed.
 - 4. Upon the kitchen hood being off, the VAV and EVAV shall return to normal operation.
 - 5. The space shall also be provided with a self-controlled space heater, the BMS shall monitor the status of the heater via a current sensor.
- M. Laundry Room Controls
 - 1. For operation of system see VRF FCU SERVING BOH SPACES and VAV AND EVAV SERVING VRF sequence. No EVAV is provided as part of this system, sequences relating to EVAV are to be ignored.
 - 2. Space includes a dryer.
 - 3. The BMS shall monitor operation of dryer via a current switch. Upon the dryer proving operational via the current sensor status the BMS shall initiate the following;
 - a. The exhaust fan shall be turned on.
 - b. The VAV shall be ramped to 400 cfm (Adj.).

4. Upon the dryer being off, the exhaust fan shall be turned off and the VAV shall return to normal operation.
 5. The space shall also be provided with a self-controlled space heater, the BMS shall monitor the status of the heater via a current sensor.
 6. Maintenance alarms are generated at the operator workstation when:
 - a. Fan Status mismatch – Fan is commanded on and the fan status is off as determined by the current sensor
- N. PPE Drying Room Controls
1. For operation of system see VRF FCU SERVING BOH SPACES and VAV AND EVAV SERVING VRF sequence.
 2. Space includes a dehumidifier and a recirculation fan.
 3. The dehumidifier system is enabled by the BMS and operates on a single interlocked "Drying Mode."
 4. Upon the space dewpoint exceeding setpoint: 55 Deg F Dewpoint (Adj.) the BMS shall initiate the following.
 - a. Circulator Fan is turned on.
 - b. Exhaust Fan is turned on.
 - c. Dehumidifier is turned on (enabled).
 - d. VRF system Room temperature setpoint changed to 80F
 - e. VAV flow setpoint changed to 300 CFM
 - f. EVAV flow setpoint changed to 0 CFM
 5. Upon the space dewpoint less than setpoint: 52 Deg F Dewpoint (Adj.) for 5 minutes the BMS shall initiate the following.
 - a. Circulator Fan is turned off.
 - b. Exhaust Fan is turned off.
 - c. Dehumidifier is turned off (disabled).
 - d. VRF system Room temperature setpoint changed to back to 75F in summer, 68F in winter.
 - e. VAV flow setpoint changed to 110 CFM
 - f. EVAV flow setpoint changed to 160 CFM
 6. The Dehumidifier shall be provided with a Condensate Pump High-Level Switch, upon activation the dehumidifier shall be turned off. The BMS shall monitor the alarm and announce at the BMS.
 7. Maintenance alarms are generated at the operator workstation when:
 - a. Fan Status mismatch – Fan is commanded on and the fan status is off as determined by the current sensor
- O. Gas Detection System and Exhaust Fan (EF-3)
- a. System Equipment
 - 1) Gas Detection system, comprising of sensors and horn strobes.
 - 2) Exhaust Fan EF-3, VFD, 0% speed output.
 - 3) Makeup air isolation damper, two position type, normally closed, fan closed
 - b. System Operation
 - 1) The Gas Detection System (GDS) shall continuously monitor carbon monoxide (CO) and nitrogen dioxide (NO₂) levels in the garage areas. It shall control the operation of the exhaust system fan based on gas concentration thresholds.

- 2) The Gas Detection System (GDS) system shall sense for high levels of CO and NO₂ gases from the cars and trucks in the garage areas.
 - 3) The system shall for a high level detection alarm activate the exhaust system and high level detection alarm which shall alarm locally and generate a BMS alarm at the BMS workstations.
 - 4) The CO and NO₂ ppm settings for the level alarms shall be programmable.
 - 5) In the event of a high level alarm, makeup isolation air damper shall be opened, the exhaust system (EF-3) shall be ramped up to setpoint to achieve design flow, contractor to coordinate with testing and balancing contractor to determine proper VFD setting.
 - 6) The BMS shall monitor the running status of the exhaust system via a current sensing relays and damper end switches.
 - 7) In the event of a high high level alarm, the exhaust system shall continue to run at 100% and the horn / strobe shall be activated. The system shall not be re-set until the system is re-set and the BMS operator has and cleared the alarm event.
 - 8) The system shall not be reset until the system is reset and the BMS operator has acknowledged and cleared the alarm event.
- c. Maintenance alarms are generated at the operator workstation when:
- 1) Fan Status mismatch – Fan is commanded on and the fan status is off as determined by the current sensor
 - 2) Damper Mismatch (isolation dampers):
 - a) Position feedback and damper command disagree for more than 120 seconds (adj).

P. Destratification Fan – (Wall Switch)

1. General
 - a. Fan, normally off.
 - b. Wall mounted switch.
2. System Off:
 - a. When the system is off, fan shall be in its normal position as stated above.
3. System Operation:
 - a. The fan shall be started/ stopped by manual operation of the wall mounted switch.
4. Monitoring
 - a. BMS shall monitor fan status
5. Maintenance alarms are generated at the operator workstation when:
 - a. Fan Status mismatch – Fan is commanded on and the fan status is off as determined by the current sensor

Q. Electric Unit Heater

1. General
 - a. BMS shall monitor space temperature and heater status.
 - b. Wall mounted or integral space thermostat shall control the unit heater by either cycling on/off or modulating the heater SCR (Silicon-controlled Rectifier) to maintain the zone temperature at setpoint (adjustable), initially set to {55 deg F}.

2. ALARMS
 - a. The BMS shall generate an alarm if the space temperature is below {50 deg F} for {10 minutes}.
- R. Emergency Generator
 1. Generator control
 - a. Emergency Generators shall be controlled by the Generator Control System (GCS) provided under Division 26. The BMS shall not issue control commands to the generator.
 2. BMS Monitoring
 - a. The controls contractor shall coordinate with approved manufacturer shop drawings to identify available monitoring points. The BMS shall monitor and annunciate the following critical generator alarms as a minimum, refer to detail for additional requirements:
 - 1) Generator status (Running, Stopped, Fault)
 - 2) Engine alarms (Overtemperature, Low Oil Pressure, Overspeed, etc.)
 - 3) Battery status
 - 4) Fuel level
 - b. All alarms shall be displayed on the BMS graphical interface and logged per the BMS alarm protocol.
- S. Automatic Transfer Switch (ATS) Monitoring
 1. ATS Control
 - a. The Automatic Transfer Switch shall be provided under Division 26 and shall be controlled by the ATS manufacturer's control system. The BMS shall not issue control commands to the ATS.
 2. BMS Monitoring
 - a. The BMS shall monitor ATS status and alarms via available outputs provided by the ATS control panel. Monitoring points may include:
 - 1) Source availability (Normal/Standby)
 - 2) Transfer status (Source 1/Source 2)
 - 3) ATS position
 - 4) Alarm or fault conditions
 3. The controls contractor shall coordinate with:
 - a. Electrical design drawings for ATS quantities and locations
 - b. Approved manufacturer shop drawings for available monitoring signals and interface requirements
 4. Alarm Handling
 - a. All ATS alarms shall be displayed on the BMS graphical interface and logged per the BMS alarm protocol. Alarm priorities shall reflect the critical nature of emergency power systems.
- T. Outdoor Weather Station Monitoring
 1. Sensor Integration.
 - a. The BMS shall monitor the following environmental parameters via hardwired outputs from the outdoor weather station:
 - 1) Outdoor Air Dry Bulb Temperature
 - 2) Outdoor Air Relative Humidity
 - 3) Outdoor Air Carbon Dioxide (CO₂) Concentration

- b. The weather station shall be furnished and installed by the controls contractor. All sensor outputs shall be connected to the BMS for real-time monitoring and trending.
 - 2. Installation Requirements
 - a. The outdoor weather station shall be installed on the north side of the building, at a location free from direct sunlight, localized heat sources, and obstructions to ensure accurate readings. Mounting height and shielding shall comply with manufacturer recommendations and industry best practices.
 - 3. Data Utilization
 - a. BMS shall use weather station data for:
 - 1) Economizer control logic
 - 2) Demand-controlled ventilation strategies
 - 3) Outdoor air quality monitoring
 - 4) Trending and diagnostics
 - 4. Alarms
 - a. Sensor failures or out-of-range values shall generate alarms per the BMS alarm protocol.
- U. Fire Smoke Damper (FSD) Control and Monitoring Sequence
 - 1. FSD Control
 - a. Fire Smoke Dampers shall be controlled by the Fire Alarm System (FAS) in accordance with local code and life safety requirements. The BMS shall not override or interfere with FAS control logic.
 - 2. FSD Monitoring
 - a. The BMS shall monitor the status of each FSD via two discrete end switches:
 - 1) Open Position Switch
 - 2) Closed Position Switch
 - b. The controls contractor shall provide wiring from each FSD to the BMS for status indication.
 - c. Refer to contract drawings for quantities and locations.
 - 3. Status Display and Alarming
 - a. FSD status shall be displayed on the BMS graphical interface, showing:
 - 1) Damper position (Open/Closed)
 - 2) Fault condition (if applicable)
 - b. Alarms
 - 1) The BMS shall generate an alarm if both switches indicate open and closed simultaneously (fault condition).
 - 2) The BMS shall generate an alarm if neither switch is active for more than 120 seconds.
 - c. Alarms shall be logged and annunciated per the BMS alarm handling protocol.
- V. Electrical Power Monitoring System
 - 1. The systems shall be provided by Div 26 and monitored by the BMS:
 - a. BMS shall monitor electrical power consumption at each electrical power meter.
 - b. BMS shall integrate to meter via BACnet or Modbus, final protocol to be determined based on approved shop drawings.

W. Plumbing Water Meter - Typical

1. The systems shall be provided by Div 22 and monitored by the BMS:
 - a. Water Meter – BMS shall monitor domestic water via pulsed input or analog input. To be determined based on final approved water meter shop drawings.

X. Fuel Oil System

1. The Fuel Oil System shall be controlled by the dedicated Fuel Oil Control System (FOCS).
2. The BMS shall not issue control commands to fuel oil pumps, valves, or tank level systems.
3. BMS shall integrate to the fuel oil system via BACnet or Modbus, final protocol to be determined based on approved shop drawings.
4. BMS Monitoring and Alarming
 - a. The BMS shall monitor and annunciate the alarms from the Fuel Oil System components, refer to approved submittal for quantities and types of available alarms.

Y. Sump Pump (Plumbing)

1. The Sump system shall be provided under Div 22 and monitored for alarms by the BMS.
2. Controls contractor to coordinate with approved manufacturer shop drawings for available alarms.

Z. Recirculation Pump (Plumbing)

1. The Recirculation Pump system shall be provided under Div 22 and monitored by the BMS.
2. Controls contractor to coordinate with approved manufacturer shop drawings.
3. Refer to contract drawings for quantities and locations.

AA. Hot box temperature monitoring

1. General
 - a. BMS shall monitor hot box temperature.
2. Alarms:
 - a. The BMS shall generate an alarm if the hot box temperature is below 40 Deg F (adj.) for 10 mins (adj.)

3.6 COMMISSIONING, TESTING AND ACCEPTANCE

- A. Refer to Section 230593 for requirements of controls system testing and balancing to be carried out by an independent contractor.
- B. The installation contractor shall perform a three-phase commissioning procedure consisting of field I/O calibration and commissioning, system commissioning and integrated system program commissioning. Document all commissioning information on commissioning data sheets as contained in this specification or alternatively on commissioning data sheets as provided by the independent controls testing contractor and submitted for review prior to the work being carried out. Commissioning work, which requires shutdown of system or deviation from normal function, shall be performed when the operation of the system is not required. The

commissioning must be coordinated with the Owner and construction manager to ensure systems are available when needed. Notify the operating personal in writing of the testing schedule so that authorized personnel from the Owner and construction manager are present throughout the commissioning procedure.

C. Field I/O Calibration and Commissioning

1. Prior to system program commissioning, verify that each control panel has been installed according to plans, specifications and approved shop drawings. Test, calibrate and bring on line each control sensor and device. Commissioning to include, but not be limited to:
 - a. Sensor accuracy at 10, 50 and 90% of range.
 - b. Sensor range.
 - c. Verify analog limit and binary alarm reporting.
 - d. Point value reporting.
 - e. Binary alarm and switch settings.
 - f. Actuator and positioner spring ranges.
 - g. Fail safe operation on loss of control signal, electric power, network communications, etc.
2. Record calibration and test data on commissioning data sheets. Sufficient space should be provided near each point name for sign off.

D. System Program Commissioning

1. After control devices have been commissioned (i.e. calibrated, tested and signed off), each DDC program shall be put on line and commissioned. The contractor shall, in the presence of the Owner demonstrate each programmed sequence of operation and compare the results in writing. In addition, each control loop shall be tested to verify proper response and stable control, within specified accuracies. System program test results shall be recorded on commissioning data sheets and submitted for record. Any discrepancies between the specification and the actual performance will be immediately rectified and retested.

E. Loop Tuning

1. The BMS contractor shall tune each control loop per ASHRAE Fundamentals IP. Tuning shall consist of adjustment of the proportional, integral, and where applicable, the derivative (PID) settings to provide stable closed-loop control. The derivative portion of loops shall not be used unless field tuning is not possible without it.
2. For all control loops, the BMS contractor shall tune the loops to ensure the fastest stable response without hunting, offset, or overshoot with the tolerances defined below. Except from a startup, maximum allowable variance from setpoint for controlled variables under normal load fluctuations shall be as follows:
 - a. Duct air temperature: $\pm 1^{\circ}\text{F}$.
 - b. Space temperature: $\pm 3^{\circ}\text{F}$ within 3 minutes and control within $\pm 2^{\circ}\text{F}$.
 - c. Chilled water temperature: $\pm 1^{\circ}\text{F}$.
 - d. Hot water temperature: $\pm 2^{\circ}\text{F}$.
 - e. Duct pressure: $\pm 0.25''$ w.g.
 - f. Water pressure: ± 1 psid.

- g. Duct humidity: +/- 3 percent when adding humidity.
 - h. Space humidity: +/- 5 percent when adding humidity to control.
 - i. Terminal air flow control: +/- 5 percent of setpoint.
 - j. Space Pressurization: +/- 0.03" w.g. with no door or window movements.
 - k. Steam Pressure: +/- 3 psig.
 - l. Water Level: +/- 5 percent tank height.
- 3. Within 3 minutes of any upset (for which the system has the capability to respond) in the control loop, the tolerances shall be maintained with exceptions as noted.
 - 4. Loop tuning shall take place during periods of high gain.
 - 5. Maintain a record of control loops that require tuning at alternate times of year.
 - 6. Document all loop tuning by capturing text, short interval trends, or screen shots of trend graphs documenting the final response.
 - a. Trend Logs:
 - 1) Trends logs are historical archives stored in the BMS that document the operation of the systems and equipment. Trends can be interval recordings of system I/O parameters or Change of Value based trends that record when a system value changes by more than a specified threshold.
 - 2) Sample times indicated as COV ($\pm$) or change of value mean that the changed parameter only needs to be recorded after the value changes by the amount listed. When output to the trending file, the latest recorded value shall be listed with any given time increment record.
 - 3) Data shall include a single row of field headings and the data thereafter shall be contiguous. Each record shall include a date and time field. Recorded parameters for a given piece of equipment or component shall be trended at the same intervals.
 - 4) Trending Requirements: As described in previous sections
 - 5) Trending to document Sequence of Operation Tests may require a more frequent interval than final trending requirements. Coordinate with the CxA to determine the correct intervals to prove operational testing and modify intervals as required.
 - 6) The BMS contractor shall set up the trends logs, ensure they are being stored properly, and then, if requested by the CxA, forward the data in electronic format to the CxA. Data shall be forwarded in one of the following formats:
 - a) Microsoft EXCEL Spreadsheet (.xls)
 - b) Comma Separated Value (.csv or .txt) preferably with quotes delimiting text fields and # delimiting date/time fields
 - 7) The CxA shall analyze trend logs of the system operating parameters to evaluate normal system functionality.
 - 8) The BMS contractor shall allow the CxA BMS access to view the trend log data and allow downloading to a remote location. The BMS contractor shall also provide instruction for accessing the trend logs.
 - b. Trend Graphs:

- 1) Trend graphs are generally used to facilitate and document testing. The BMS contractor shall prepare controller and workstation software to display graphical trends.
- 2) On the trend graphs, lines shall be labeled and shall be distinguishable from each other by using either different line types, or different line colors.
- 3) Indicate engineering units of the y-axis values; e.g. °F, inches w.g., Btu/lb, percent wide open, etc. The y-axis scale shall beset such that all trended values are in a readable range.
- 4) Trend outside air temperature, humidity, and enthalpy during each period in which any other points impacted by these parameters are trended.
- 5) All points trended for one HVAC subsystem (e.g. air handling unit, chilled water system, etc.) shall be trended during the same trend interval. On renovation projects with existing to remain controls on air or water generation equipment, these trend graphs need only address the new BMS renovation work.
- 6) Each graph shall be clearly labeled with HVAC subsystem title, date, and times.
- 7) The BMS contractor shall forward the trend graphs as part of the CxA BMS Pre-Requisite Package to the CxA for review.

F. Integrated System Commissioning:

1. After all DDC programs have been commissioned, the contractor shall verify the overall system performance as specified. Tests shall include, but not be limited to the following:
2. Data communication, both normal and failure modes.
3. Fully loaded system response time.
4. Impact of component failures on system performance and system operation.
5. Time/Date changes.
6. End of month/ end of year operation.
7. Season changeover.
8. Global application programs and point sharing.
9. System backup and reloading.
10. System status displays.
11. Diagnostic functions.
12. Power failure routines.
13. Battery backup.

G. Acceptance Testing

1. Submit for approval, a detailed acceptance test procedure designed to demonstrate step by step testing of all BMS related sequences, systems and equipment, integration with external systems and compliance with contractual requirements. This Acceptance test procedure will take place after the commissioning procedure, in addition to the testing described above the testing will verify that sensors and control devices maintain specified accuracies and the system performance does not degrade over time.
2. Using the commissioning test data sheets, the contractor shall demonstrate all point types as required by Owner/engineer. The contractor shall supply all

instruments for testing and turn over same to the Owner after acceptance testing.

- a. All test instruments shall be submitted for approval.

H. Test instrument accuracy

Temperature:	1/4°F or 1/2% full scale, whichever is less.
High Pressure (psi):	1/2 psi or 1/2% full scale, whichever is less.
Low Pressure (in w.c.):	1/2% of full scale
Humidity:	2% RH
Electrical:	1/4% full scale

1. Test instruments to be factory calibrated with calibration certificates provided valid at least 6 months from installation.

I. Commissioning Testing Support

1. System verification testing is part of the Commissioning Process.
2. Verification testing shall be performed by the contractor and witnessed and documented by the Engineer.
3. The commissioning process requires detailed O&M documentation.
4. The controls contractor shall assist the commissioning authority with performing verification and performance testing. This includes the following:
 - a. Attend Commissioning (Cx) progress and coordination meetings.
 - b. Prepare and submit required draft forms and systems information.
 - c. Establish trend logs of system operation as specified herein.
 - d. Demonstrate system operation.
 - e. Manipulate systems and equipment to facilitate testing.
 - f. Provide instrumentation necessary for verification and performance testing.
 - g. Manipulate control systems to facilitate verification and performance testing.
 - h. Provide a BMS technician(s) to work at the direction of the commissioning authority for software optimization assistance.
5. Software Optimization Assistance
 - a. At no additional cost to owner, controls contractor will provide the services of a BMS technician as specified above at the project site and at the disposal of the commissioning authority and owner. The purpose of this requirement is to make changes, enhancements, and additions to the control unit and/or workstation software that have been identified during the construction and commissioning of the project in order to complete functional testing and the integrated systems test.
 - b. The BMS technician will be thoroughly trained in the programming and operation of the controller and workstation software. If the BMS technician provided cannot perform every software task requested by the commissioning authority and owner in a timely fashion, the controls contractor will provide additional qualified personnel at the project site in order to meet the total specified requirements on-site.

J. Verification Testing

1. System verification testing is part of the Commissioning Process. Verification testing shall be performed by the contractor and witnessed and documented by the Engineer. The commissioning process requires detailed O&M documentation.

3.7 CLOSEOUT

A. Substantial completion requirements:

1. Provide final cleaning immediately prior to substantial completion inspection.
2. Corrective work:
 - a. Remove, repair and reinstall, or restore in place damaged items.
 - b. Replace damaged materials or items with new if repair not acceptable to Architect.
3. Provide product data to complete operation & maintenance manuals.
4. Submit executed warranties.

3.8 DEVICE AND INPUT/OUTPUT SCHEDULE

- A. Refer to design drawings for device and input/output schedules.

END OF SECTION 230923

SECTION 23 11 13

FACILITY FUEL-OIL PIPING

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fuel-oil pipes, tubes, and fittings.
2. Double-containment pipe and fittings.
3. Piping specialties.
4. Joining materials.
5. Specialty valves.
6. Mechanical leak-detection valves.
7. Leak-detection and monitoring system.
8. Labels and identification.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, and dimensions of individual components and profiles.
2. Include rated capacities, pressure ratings, operating characteristics, electrical characteristics, settings, and furnished specialties and accessories.

B. Shop Drawings: For fuel-oil piping.

1. Include plans, elevations sections, hangers, and supports for multiple pipes.
2. Include details of location of anchors, alignment guides, and expansion joints and loops.
3. Scale: 1/4 inch per foot (1:50)

- C. Delegated Design Submittals: For fuel-oil piping and supports, and seismic restraints indicated to comply with performance requirements and design criteria.
 - 1. Include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 2. Detail fabrication and assembly of anchors and seismic restraints.
 - 3. Design Calculations: Calculate requirements for selecting seismic restraints.
 - 4. Detail fabrication and assembly of pipe anchors, hangers, supports for multiple pipes, and attachments of the same to building structure.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings:
 - 1. Plans and details, or Building Information Model (BIM), drawn to scale, on which fuel-oil piping and tanks are shown and coordinated with other installations, using input from installers of the items involved.
- B. Brazing certificates.
- C. Welding certificates.
- D. Seismic qualification certificate.
- E. Field quality-control reports.
- F. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuel-oil equipment and accessories.
 - 1. Indicate actual installed items by marking submittals with an arrow or box.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish extra materials, from the same production run, to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1.6 QUALITY ASSURANCE

- A. Delegated Design Engineer Qualifications: A professional engineer who is legally qualified to practice in Massachusetts where Project is located and who is experienced in providing engineering services of the type indicated.
- B. System Supplier Qualifications: The system supplier shall have at least five (5) years of experience in the manufacture of secondary contained pipe systems.
- C. Brazing: Qualify processes and operators in accordance with ASME Boiler and Pressure Vessel Code: Section IX.
- D. Steel Support Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- E. Pipe Welding Qualifications: Qualify procedures and personnel in accordance with ASME Boiler and Pressure Vessel Code.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Lift and support fuel-oil storage tanks only at designated lifting or supporting points, as indicated on Shop Drawings. Do not move or lift tanks unless empty.
- 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 PE and PE-coated pipes, tubes, and valves in manner to avoid damaging the coating and to protect from direct sunlight.

1.8 FIELD CONDITIONS

- A. Interruption of Existing Fuel-Oil Service: Do not interrupt fuel-oil service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary fuel-oil supply in accordance with requirements indicated:
 - 1. Notify Owner no fewer than two days in advance of proposed interruption of fuel-oil service.
 - 2. Do not proceed with interruption of fuel-oil service without Owner's written permission.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of flexible, double-containment piping and related equipment that fail in materials or workmanship within specified warranty period.
 - 1. Failures include those due to defective materials or workmanship for materials including piping, dispenser sumps, watertight sump entry boots, terminations, and other end fittings.
 - 2. Warranty Period: 10 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 an NRTL, and marked for intended location and use.
- B. Comply with ASME B31.9, "Building Services Piping," for fuel-oil piping materials, installation, testing, and inspecting.
- C. Fuel-Oil Valves: Comply with UL 842 and have service mark initials "WOG" permanently marked on valve body.
- D. Comply with requirements of the EPA and of state and local authorities having jurisdiction.
- E. Maximum Operating-Pressure Ratings: 3 psig (21 kPa)-oil supply pressure at oil-fired appliances.
- F. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation, supports, anchors, and seismic restraints and multiple pipe supports and hangers for fuel-oil piping, using performance requirements and design criteria indicated.
- G. Seismic Performance: Fuel-oil piping and associated components to withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment".

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. Component Importance Factor: 1.5.

2.2 FUEL-OIL PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: Standard weight or extra heavy, ASTM A106 Grade B seamless beveled for welding.
- B. Joints: All joints for pipe 1/2" and larger shall be butt-welded. Sizes 2" and smaller shall be socket-welded.
 1. Wrought-Steel Welding Fittings: ASTM A234/A234M, for butt and socket welding.
 2. 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: butt welding to match pipe.
 - c. Lapped Face: Not permitted underground.
 - d. Gasket Materials: Asbestos free, ASME B16.20 metallic, or ASME B16.21 nonmetallic; gaskets compatible with fuel oil.
 - e. Bolts and Nuts: ASME B18.2.1, zinc alloy-plated steel.
 3. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
 - a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.

2.3 DOUBLE-CONTAINMENT PIPE AND FITTINGS

- A. Double-Containment Piping - Rigid:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conley Composites; an Andronaco Industries Co.
 - b. Franklin Fueling Systems.
 - c. Tricon Piping System.
 - d. PermAlert.
 - e. Smith Fiberglass; a National Oilwell Varco brand.
 - f. Tricon Piping Systems, Inc.
 2. Description: All secondary containment piping systems shall be an engineered and totally factory fabricated double-pipe type containment system.

3. Source Limitations: Obtain double-containment piping - rigid, from single manufacturer.
4. Standard: Comply with UL 971.
5. Carrier Pipe: As specified in "Fuel-Oil Pipes, Tubes, and Fittings" Article (ASTM A106 Seamless).
6. Containment Pipe (Above Grade): The outer conduit shall be a smooth wall, Schedule 10 steel conforming to ASTM Specification A-135, Grade A ERW. Factory coated with Red Oxide Primer up to 3-4 mils dry film thickness.
7. Containment Pipe (Below Grade): The outer conduit shall be a nonmetallic fiberglass (RTRP) conforming to ASTM 2310 standard classification TRP-11CX and ASTM D2996.
8. Fittings: Factory fabricated to job dimensions designed to minimize the number of field connections.
9. Factory Testing: All factory joints to be 100 percent pressure tested.
10. RTRP: ASTM D2996 or ASTM D2997 carrier and containment piping and mechanical couplings to seal carrier and containment piping or individually bonded joints.
 - a. Minimum Operating-Pressure Rating for RTRP NPS 2 and NPS 3 (DN 50 and DN 80): 150 psig (1035 kPa).
 - b. Minimum Operating-Pressure Rating for RTRP NPS 4 and NPS 6 (DN 100 and DN 150): 125 psig (860 kPa). Compliance with UL 971 is not required for NPS 6 (DN 150) and larger piping.
 - c. Fittings: RTRF complying with ASTM D2996 or ASTM D2997 and made by RTRP manufacturer; watertight sump entry boots, termination, or other end fittings.
11. Leak-Detection System: 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.

2.4 PIPING SPECIALTIES

A. Flexible Connectors - Metallic:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. FLEX-ING, Inc.
 - b. Flexicraft Industries.
 - c. Hose Master, Inc.
 - d. Hosecraft USA; a division of Flexicraft Industries.
 - e. Kadant Unaflex, LLC.
 - f. Metraflex Company (The).
 - g. Proco Products, Inc.
 - h. UIP International, Inc.
 - i. Tricon Piping System

2. Source Limitations: Obtain flexible connectors - metallic, from single manufacturer.
3. Listed and labeled for aboveground and underground applications by an NRTL acceptable to authorities having jurisdiction.
4. Stainless steel bellows with woven, flexible, bronze or stainless steel, wire-reinforcing protective jacket.
5. Minimum Operating Pressure: 150 psig (1035 kPa).
6. End Connections: Socket, flanged, or threaded end to match connected piping.
7. Maximum Length: 30 inches (762 mm).
8. Swivel end, 50 psig (345 kPa) maximum operating pressure.
9. Factory-furnished anode for connection to cathodic protection.

B. Strainers - Y-Pattern:

1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Flanged ends for NPS 2 (DN 50) and smaller.
3. Strainer Screen: 60-mesh startup strainer and perforated stainless steel basket with 50 percent free area.
4. CWP Rating: 125 psig (860 kPa).

C. Air Vents - Manual:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2 (DN 15).
5. Discharge Connection: NPS 1/8 (DN 6).
6. CWP Rating: 150 psig (1035 kPa).
7. Maximum Operating Temperature: 225 deg F (107 deg C).

2.5 JOINING MATERIALS

- A. Joint Compound and Tape for Threaded Joints: Suitable for fuel oil.
- 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. Bonding Adhesive for RTRP: As recommended by piping and fitting manufacturer.

2.6 SPECIALTY VALVES

A. Pressure Relief Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anderson Greenwood; Pentair, Ltd.
 - b. Fulflo Specialties, Inc.
 - c. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company.
 - d. Webster Fuel Pumps & Valves; a division of Capital City Tool, Inc.
2. Source Limitations: Obtain pressure relief valves from single manufacturer.
3. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
4. Body: Brass, bronze, or cast steel.
5. Springs: Stainless steel, interchangeable.
6. Seat and Seal: NBR.
7. Orifice: Stainless steel, interchangeable.
8. Factory-Applied Finish: Baked enamel.
9. Maximum Inlet Pressure: 150 psig (1035 kPa)
10. Relief Pressure Setting: 60 psig (414 kPa)

B. Oil Safety Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anderson Greenwood; Pentair, Ltd.
 - b. Fulflo Specialties, Inc.
 - c. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company.
 - d. Webster Fuel Pumps & Valves; a division of Capital City Tool, Inc.
2. Source Limitations: Obtains oil safety valves from single manufacturer.
3. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
4. Body: Brass, bronze, or cast steel.
5. Springs: Stainless steel.
6. Seat and Diaphragm: NBR.
7. Orifice: Stainless steel, interchangeable.
8. Factory-Applied Finish: Baked enamel.
9. Manual override port.
10. Maximum Inlet Pressure: 60 psig (414 kPa)
11. Maximum Outlet Pressure: 3 psig (21 kPa)

C. Emergency Shutoff Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. EMCO Wheaton.
 - b. Franklin Fueling Systems.
 - c. OPW Engineered Systems; OPW Fluid Transfer Group; a Dover company.
2. Source Limitations: Obtain emergency shutoff valves from single manufacturer.
3. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
4. Single poppet valve.
5. Body: ASTM A126, cast iron.
6. Disk: FPM.
7. Poppet Spring: Stainless steel.
8. Stem: Plated brass.
9. O-Ring: FPM.
10. Packing Nut: PTFE-coated brass.
11. Fusible link to close valve at 165 deg F (74 deg C).
12. Thermal relief to vent line pressure buildup due to fire.
13. Air test port.
14. Maximum Operating Pressure: 0.5 psig (3.45 kPa).

2.7 MECHANICAL LEAK-DETECTION VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Franklin Fueling Systems.
 2. Red Jacket Pumps.
 3. Vaporless Manufacturing, Inc.
- B. Source Limitations: Obtain mechanical leak-detection valves from single manufacturer.
- C. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
- D. Body: ASTM A126, cast iron.
- E. O-Rings: Elastomeric compatible with fuel oil.
- F. Piston and Stem Seals: PTFE.

- G. Stem and Spring: Stainless steel.
- H. Piston Cylinder: Burnished brass.
- I. Indicated Leak Rate: Maximum 3 gph (3 mL/s) at 10 psig (69 kPa)
- J. Leak Indication: Reduced flow.

2.8 LEAK-DETECTION AND MONITORING SYSTEM

A. Cable and Sensor Leak-Detection Monitoring System:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Caldwell Systems Corporation.
 - b. Containment Solutions, Inc.
 - c. Franklin Fueling Systems.
 - d. Gems Sensors & Controls Inc.
 - e. Highland Tank & Manufacturing Company, Inc.
 - f. In-Situ, Inc.
 - g. MSA Safety, Inc.
 - h. Pentair Thermal Management.
 - i. PermAlert.
 - j. Pneumercator Inc.
 - k. Red Jacket Pumps.
2. Source Limitations: Obtain cable and sensor leak-detection monitoring system from single manufacturer.
3. Standard: Comply with UL 1238.
4. Calibrated leak-detection and monitoring system with probes and other sensors and remote alarm panel for fuel-oil piping.
5. Include fittings and devices required for testing.

2.9 LABELS AND IDENTIFICATION

- A. Detectable Warning Tape: Acid- and alkali-resistant PE-film warning tape manufactured for marking and identifying underground utilities, minimum of 6 inches (152 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with description of utility, with metallic core encased in a protective jacket for corrosion protection, and detectable by metal detector when tape is buried up to 30 inches (762 mm) deep; colored yellow.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas for compliance with requirements for installation tolerances and other conditions affecting performance of fuel-oil piping.
- B. Examine installation of fuel-burning equipment and fuel-handling and storage equipment to verify actual locations of piping connections before installing fuel-oil piping.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EARTHWORK

- A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.
- B. Backfill Requirements: A 4-inch layer of sand or fine gravel, less than 1-1/2 inches in diameter, shall be placed and tamped in the trench to provide uniform bedding for the containment system. Once the system is in place, the trenches shall be carefully backfilled with similar material and hand tamped in 6-inch layers until a minimum of 12 inches above the top of the containment pipe has been achieved.
- C. The remainder of the backfill shall be void of rocks, frozen earth, and foreign material.

3.3 PREPARATION

- A. Close equipment shutoff valves before turning off fuel oil to premises or piping section.
- B. Comply with NFPA 30 and NFPA 31 requirements for prevention of accidental ignition.

3.4 INSTALLATION OF OUTDOOR PIPING

- A. Underground Fuel oil piping: No Piping shall be installed in standing water. Trenches shall be maintained dry until final field closure is complete. Burial Depth:

1. Under Compacted Backfill: 18 inches (457 mm) below finished grade.
2. Under Asphalt 2 Inches (51 mm) Thick: 8 inches (203 mm) below bottom of asphalt.
3. Under 4 Inches (102 mm) of Reinforced Concrete in Areas Subject to Vehicle Traffic: 4 inches (102 mm) below bottom of concrete.
4. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

B. 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, complying with protective coating manufacturer's written instructions. Review protective coating damage with Architect prior to repair.
 3. Replace pipe having damaged PE coating with new pipe.
- C. Install double-containment, fuel-oil pipe at a minimum slope of 1 percent downward toward fuel-oil storage tank sump.
- D. Install vent pipe at a minimum slope of 2 percent downward toward fuel-oil storage tank sump.
- E. Assemble and install entry boots for pipe penetrations through sump sidewalls for liquidtight joints.
- F. Install metal pipes and tubes, fittings, valves, and flexible connectors at piping connections to aboveground storage tanks and underground storage tanks.
- G. Install fittings for changes in direction in rigid pipe.
- H. Install system components with pressure rating equal to or greater than system operating pressure.

3.5 INSTALLATION OF INDOOR PIPING

- A. 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.

- B. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction to allow for mechanical installations.
- 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 at a height that allows sufficient space for ceiling panel removal.
- F. Install piping free of sags and bends.
- G. Install fittings for changes in direction and branch connections.
- H. Comply with requirements for equipment specifications for roughing-in requirements.
- I. Conceal pipe installations in walls, pipe spaces, or utility spaces; above ceilings; below grade or floors; and in floor channels unless indicated to be exposed to view.
- J. Prohibited Locations:
 - 1. Do not install fuel-oil piping in or through HVAC ducts and plenums, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
 - 2. Do not install fuel-oil piping in solid walls or partitions.
- K. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- L. Connect branch piping from top or side of horizontal piping.
- M. Install unions in pipes NPS 2 (DN 50) and smaller at final connection to each piece of equipment and elsewhere as indicated. Unions are not required on flanged devices.
- N. Do not use fuel-oil piping as grounding electrode.

- O. Install sleeves and sleeve seals for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230500 "Common Work Results for HVAC."
- P. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230500 "Common Work Results for HVAC."

3.6 INSTALLATION OF VALVES

- A. Install manual fuel-oil shutoff valves on branch connections to fuel-oil appliance.
- B. Install valves in accessible locations.
- C. Install oil safety valves at inlet of each oil-fired appliance.
- D. Install pressure relief valves in distribution piping between the supply and return lines.
- E. Install one-piece, bronze ball valve with hose end connection at low points in fuel-oil piping. Comply with requirements in Section 230523 "General-Duty Valves for HVAC Piping."
- F. Install manual air vents at high points in fuel-oil piping.
- G. Install emergency shutoff valves at dispensers.

3.7 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. Welded Joints: Construct joints in accordance with AWS D10.12/D10.12M, using qualified processes and welding operators in accordance with "Quality Assurance" Article.
 - 1. Bevel plain ends of steel pipe.

- 2. Patch factory-applied protective coating as recommended in writing by manufacturer at field welds and where damage to coating occurs during construction.
- D. Brazed Joints: Construct joints in accordance with AWS's "Brazing Handbook," Ch. 35, "Pipe and Tubing."
- E. Fiberglass-Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join in accordance with pipe manufacturer's written instructions.

3.8 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Comply with requirements for hangers, supports, and anchor devices specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- C. Install hangers for steel piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- D. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.
- E. Support vertical runs of copper tube and steel piping to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.9 INSTALLATION OF LEAK-DETECTION AND MONITORING SYSTEM

- A. Install leak-detection and monitoring system. Install alarm panel inside building where indicated.
- B. Double-Containment, Fuel-Oil Piping: Install leak-detection sensor probes at low points in piping

3.10 PIPING CONNECTIONS

- A. Where installing piping adjacent to equipment, allow space for service and maintenance.

- B. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment having welded pipe connection.
- C. Connect piping to equipment with shutoff valve and union. Install union between valve and equipment.
- D. Install flexible piping connectors at final connection to burners, oil-fired appliances, and day tanks.

3.11 LABELING AND IDENTIFYING

- A. Nameplates, pipe identification, valve tags, and signs are specified in Section 230553 "Identification for HVAC Piping and Equipment."
- B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on or near each service regulator, service meter, and earthquake valve.
 - 1. Text: In addition to identifying unit, distinguish between multiple units; inform operator of operational requirements; indicate safety and emergency precautions; and warn of hazards and improper operations.
- C. Install detectable warning tape directly above buried fuel-oil piping, 12 inches (304 mm) below finished grade, except 6 inches (152 mm) below subgrade under pavements and slabs. Terminate tracer wire in an accessible area, and identify as "tracer wire" for future use with plastic-laminate sign.
 - 1. Piping: Over underground fuel-oil distribution piping.

3.12 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer Field Services: Engage a factory-authorized service representative to support field tests and inspections.
- C. Tests and Inspections:
 - 1. Piping Pressure Test: Minimum hydrostatic or pneumatic test-pressures measured at highest point in system.
 - a. Fuel-Oil Distribution Piping:

- 1) Hydrostatic: Minimum 150 percent of maximum anticipated pressure or 5 psig (35 kPa)
 - 2) Pneumatic: Minimum 110 percent of maximum anticipated pressure.
 - 3) Pressure to be maintained while complete visual inspection of all joints and connections is conducted.
 - 4) In no case is test pressure to be less than a gauge pressure of 5 psi (35 kPa) measured at the highest point of the system.
 - 5) In no case is test pressure to be maintained for less than 10 minutes.
- b. Fuel-Oil, Double-Containment Piping:
 - 1) Carrier Pipe: Same as "Fuel-Oil Distribution Piping" Subparagraph above.
 - 2) Containment Conduit (Non-Metallic/Below Grade): Test to Minimum 5 psig (35 kPa).
 - 3) Containment Conduit (Metallic/Above Grade): Test to 15 psig.
 - 4) Duration: The test shall be maintained for a minimum time of 1 hour.
 - c. Suction Piping: Minimum 20 in. Hg (500 mm Hg) for minimum 30 minutes.
 - d. Isolate storage tanks if test pressure in piping will cause pressure in storage tanks to exceed 10 psig (69 kPa).
- D. Inspect and test fuel-oil piping in accordance with NFPA 31, "Tests of Piping" Paragraph; and in accordance with requirements of authorities having jurisdiction.
 - E. Test leak-detection and monitoring system for accuracy by manually operating sensors and checking against alarm panel indication.
 - F. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - G. Bleed air from fuel-oil piping using manual air vents.
 - H. Fuel-oil piping and equipment will be considered defective if they do not pass tests and inspections.
 - I. Prepare test and inspection reports.

3.13 OUTDOOR PIPING SCHEDULE

- A. Underground Fuel-Oil Piping: Rigid, double-containment piping. Size indicated is carrier-pipe size.
- B. Underground fuel-oil-tank fill and vent piping to be the following:

1. NPS 2 (DN 50) Pipe Size and Smaller: Steel pipe, steel or welded joints. Coat pipe and fittings with protective coating for steel piping.
 2. NPS 2-1/2 (DN 65) Pipe Size and Larger: Steel pipe, steel welding fittings, and welded joints. Coat pipe and fittings with protective coating for steel piping.
- C. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
- D. Aboveground fuel-oil piping: Rigid, double-containment piping:
1. NPS 2 (DN 50) Pipe Size and Smaller: Steel pipe, steel or welded joints.
 2. NPS 2-1/2 (DN 65) Pipe Size and Larger: Steel pipe, steel welding fittings, and welded joints.

3.14 INDOOR PIPING SCHEDULE

- A. Aboveground fuel-oil piping: Rigid, double-containment piping::
1. NPS 1/2 (DN 15) Pipe Size and Smaller: Steel pipe with welded joints
 2. NPS 5/8 to NPS 2 (DN 18 to DN 50): Steel pipe with welded joints

3.15 SHUTOFF VALVE SCHEDULE

- A. Valves for aboveground distribution piping NPS 2 (DN 50) and smaller to be the following:
1. One-piece, bronze ball valve with bronze trim.
 2. Two-piece, full -port, bronze ball valves with bronze trim.
- B. Distribution piping valves for pipe NPS 2-1/2 (DN 65) and larger to be 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 to be the following:
1. One-piece, bronze ball valve with bronze trim.
 2. Two-piece, full port, bronze ball valves with bronze trim.

END OF SECTION 231113

SECTION 23 12 13

FACILITY FUEL-OIL PUMPS

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Duplex fuel-oil pumps.
2. Fuel-oil pump control centers.
3. Fuel-oil polishing system.
4. Hot box.

B. Related Requirements:

1. Section 23 11 13 "Facility Fuel-Oil Piping."
2. Section 23 13 13 "Facility Underground Fuel-Oil Storage Tanks."

1.2 ACTION SUBMITTALS

A. Submittal Compliance

1. Comparison Schedule:
 - a. Submit a schedule to indicate performance of equipment scheduled on Drawings directly compared to performance of submitted equipment.
 - b. In instances when more than 5 submittals are provided with a single submission, the time period for review will be extended and the release of submittals will be coordinated based on contractors' priority for release of equipment.
 - c. Clearly identify each line in schedule to indicate "Scheduled" where indicating performance scheduled on Drawings and "Submitted" where indicating performance of submitted equipment.
 - d. Organize schedule to first indicate performance scheduled on Drawings on one line followed by line directly below that indicates performance of submitted equipment.
 - e. Comparison schedule shall follow arrangement and organization of scheduled information indicated on Drawings.

- f. Submitted equipment shall have a value for each scheduled value indicated.
 - 2. Contractor to submit a specification compliance document. This is to note acceptance or deviation from all sections in the specifications.
 - 3. All submittals to be digital and searchable. Scanned submittals are not acceptable.
 - 4. Action submittals are submittals requiring responsive action and return of reviewed documents to Contractor.
- B. Product Data: For each type of product.
- 1. Include construction details, material descriptions, and dimensions of individual components and profiles.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- C. Shop Drawings: For fuel-oil pumps and fuel-oil polishing system.
- 1. Include construction details and dimensions of individual components for fuel-oil pumps and fuel-oil polishing system.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Scale: 1/4 inch per foot (1:50).

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans and details, or Building Information Model (BIM), drawn to scale, showing items described in this Section and coordinated with all building trades.
- B. Sample Warranties: For fuel-oil pumps and fuel-oil polishing system.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuel-oil pumps and fuel-oil polishing system.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Extra Stock Material: Furnish extra materials, from the same production run, to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
- B. Drive Belt: One for each belt-driven pump.

1.6 QUALITY ASSURANCE

- A. Delegated Design Engineer Qualifications: A professional engineer who is legally qualified to practice in Massachusetts where Project is located and who is experienced in providing engineering services of the type indicated.
- B. The backflow prevention assembly enclosure manufacturer shall be a company specializing in the manufacture of backflow prevention assembly enclosures with at least 30 years of successful experience designing and selling enclosures to various customers in different climatic regions.

1.7 WARRANTY

- A. Manufacturer Warranty: Manufacturer and installer agree to repair or replace fuel-oil pumps and fuel-oil polishing systems that fail in materials or workmanship within specific warranty period.
- B. Warranty Period for Fuel-Oil Pumps: 1 year warranty that expires 18 months from the date of shipment or 12 months from the date of start-up, whichever comes first.
- C. Warranty Period for Fuel-Oil Polishing Systems: 1 year warranty that expires 18 months from the date of shipment or 12 months from the date of start-up, whichever comes first.

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 use.
- B. Maximum Operating-Pressure Ratings: 3 psig fuel-oil supply pressure at oil-fired appliances.
- C. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.

2.2 DUPLEX FUEL-OIL TRANSFER PUMP SETS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Hayes Pump.
 - 2. Preferred Utilities Manufacturing Corporation.
 - 3. Simplex.
- B. Comply with UL 79, UL 87, and UL 343.
- C. Provide and install factory assembled "Packaged" Duplex Fuel Oil Pump Set as manufactured by Hayes Pump or approved equal.
- D. The set shall be piped and wired, with components mounted on a steel base support fabricated of steel plate with 4" steel side rails continuously welded to the base. The base support to be fabricated with 3" overflow containment lip and base shall extend beyond any fitting, valve, pump, strainer or selector valve. Any fuel leaking from any component, fitting, or packing in the system shall be contained by this base plate. Base shall be grouted in the field to the housekeeping pad to minimize vibration and movement. In the Rupture Basin shall be a switch for leak detection. Visual and audible alarm and annunciation for the pump set rupture basin shall be located on the pump set control cabinet. Provide a 1/2" plugged drain connection in the Rupture Basin. The base shall be provided with steel brackets for mounting and support of the electrical control cabinet. Pipe shall be schedule 80

black pipe with malleable 300# pipe fittings. Each pump shall be selected for a fluid viscosity of 100 SSU with a motor RPM as scheduled.

- E. Pump Assembly: The pump assembly shall consist of the following items, mounted, precision aligned, painted and tested.
 - 1. The pump shall be of the positive displacement internal gear, rotary type, with mechanical face type seal, internal spring-loaded adjustable bypass type pressure relief valve, and a three-bolt flange mounted foot. The pump shall be capable of delivering capacity as shown on plans. The pump shall be capable of developing 25" Hg. vacuum at 0 psig as factory tested, however for normal operation, vacuum shall not exceed 15" Hg. Pump housing shall be designed to permit disassembly without breaking piping connections. The pump rotor assembly is to be in hydraulic axial balance to eliminate end thrust.
 - 2. Materials of Construction: The pump housing, housing cover, and mounting foot shall be gray cast iron. The mechanical face type seal rotating ring shall be carbon, the stationary seat shall be ni-resist, and the seal elastomer shall be suitable for the fluid pumped.
- F. Pumps and motors shall be mounted on a structural steel channel and equipped with flexible coupling and full OSHA coupling guard. Pumps and motors shall be mounted bolts threaded into the steel channel for ease of maintenance. Mounting bolts shall not penetrate the secondary containment basin.
- G. Flexible coupling general: The pump shall be connected to the motor by an elastomeric jaw type flexible coupling that does not require lubrication. The coupling wear member shall be replaceable without disturbing the alignment of either the pump or motor. Sizing of the flexible coupling shall be based on motor horsepower and rpm. Materials of construction: The coupling body shall be sintered iron and east iron. The elastomeric wear member shall be NBS Rubber.
- H. Motor General: The motor shall be TEFC, rigid base, standard NEMA frame. Materials of construction: The motor shall have copper windings, a dynamically balanced rotor, ball bearings, and a heavy gauge steel NEMA frame.
- I. Coupling guard general: The coupling guard shall be an OSHA type.
- J. One (1) duplex fuel oil strainer for the suction side of each pump set, sized to produce less than 1/2 inch of mercury drop through a clean strainer basket with the maximum anticipated flow in the suction line. Strainer shall have one-piece cast-

iron body and shall be suitable for pressure to 200 psi. Strainer shall come complete with lever wrench handle. Strainer to be No. 53.

- K. Two (2) fuel oil pump relief valves piped sized to relieve the full flow of the pump without causing the pump motor to overload or any component's pressure rating to be exceeded if the discharge is inadvertently valved off. Valves shall be externally mounted on the set to be piped to the return line in the field according to NFPA 30, 5-4.1.5. Internal relief valves will not be accepted.
- L. Provide one (2) class 150, threaded, bronze body, check valves. Valves shall be located on the discharge side of each pump.
- M. Ball valves shall be provided on both sides of each pump to provide pump isolation for service. Valves shall be class 150.
- N. One (1) 4" dial compound gauge, one on each side of suction strainer. Gauges shall be liquid filled to dampen pulsation, with bright finished stainless steel case, brass movement, bronze bourdon tube, and shall be furnished with a pulsation dampening orifice. All gauges shall be readable from the front of the set, at a distance of not less than 20 feet. Gauge shall read 30" vacuum - 15 psig. Gauges shall be mounted with isolation cocks.
- O. Two (2) 4" dial pressure gauges to be placed on discharge side of each pump. The gauges shall be liquid filled to dampen pulsation, have bright finished stainless steel case, brass movement, bronze bourdon tube, and shall be furnished with a pulsation dampening orifice. All gauges shall be readable from the front of the set, at a distance of not less than 20 feet. Gauge shall read 0 - 160 PSIG. Gauges shall be mounted with isolation cocks.
- P. Provide a time delayed flow sensing switch on the discharge of the pump set to bring on the lag pump should one of the pumps fail to maintain flow in the loop. Switch will be wired back to the main control cabinet for alarm and annunciation.

2.3 FUEL-OIL PUMP CONTROL CENTERS

- A. Cabinet enclosure shall be constructed to NEMA 12 standards and comply with UL 353 and UL 508C. Cabinet shall consist of but not be limited to the following:

1. Thru-door AC line disconnect switch if voltage greater than 120V.
2. Magnetic motor starters with overload protection.
3. Motor circuit breakers.
4. Hand-off-Auto switches for each pump.
5. Flow switch with TDR for lag pump
6. Lead pump selector switch, with alternating lead lag.
7. Alarm bell with silence push-button.
8. Control circuit transformer if voltage greater than 120V.
9. ETM Time elapse recorders to measure running time for each pump.
10. Motor leak alarms
11. Common alarm outputs to interface with the BMS. Refer to fuel oil system controls detail for outputs required.
12. Alarm and annunciation for each leak switch in the containment pipe that runs throughout the building. See controls drawings for detail.

B. Indicating lights as follows:

1. Pump running (2).
2. Pump failure.
3. Pump set rupture basin.
4. High day tank level.
5. Low day tank level.
6. Day tank leak.
7. Containment pipe leak.
8. Motor Leak (2).
9. Strainer dirty

2.4 FUEL-OIL POLISHING SYSTEM

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

1. Fuel Technologies, International, LLC.
2. Preferred Utilities Manufacturing Corporation.
3. Earthsafe Systems, Inc
4. Or approved equal.

B. Source Limitations: Obtain fuel-oil polishing system from single manufacturer.

C. Description: Factory-fabricated and -wired fuel-oil polishing system for fuel-oil filtration; with enclosure, filter, fuel-oil pump, and controls.

1. Enclosure: NEMA 250, Type 3R, painted steel containing pumps, filters, accessories, and controls. Hinged door on the front of enclosure.
2. Pump: Comply with HI 3.1-3.5, steel gear with crescent, positive-displacement, direct-coupled, rotary type.
3. Materials: Cast-iron housing; bronze bearings; steel shaft; mechanical seals; and built-in, pressure relief bypass valve.
4. Piping: Steel with malleable-iron fittings and threaded joints or wrought-steel fittings and welded joints.
5. Spin-on, Replaceable, Multistage Filters:
 - a. Stage 1: Particulate removal to 2 microns.
 - b. Stage 2: Water separation to 5 PPM.
6. Programmable Logic Controller:
 - a. Provide fully automatic operation of system.
 - b. Alarm on maximum 15-in. Hg vacuum at pump suction indicating plugged filter.
 - c. Alarm on high water level in filter.
 - d. Alarm leak in enclosure.
 - e. Touch screen; with minimum 2-line, 20-character, backlit, LCD display.
 - f. Display pressure differential across filter.
 - g. Display pressure differential across coalescer.
 - h. Controller strip heater with thermostat.
7. Fuel-Quality Analyzer: Continuously monitors fuel quality to detect and record particulate contamination and presence of water.
8. Interface with automatic control system is specified in Section 230900 "Building Management System" to control and indicate the following:
 - a. Start/stop system when required by schedule.
 - b. Operating status.
 - c. Alarm off-normal status.

2.5 HOT BOX

A. ACCEPTABLE MANUFACTURERS

1. Hot Box®
2. Safe-T-Cover
3. AquaSHIELD or Engineer approved equal.

B. REFERENCES

1. ASSE 1060-Performance Requirements for Outdoor Enclosures for Backflow Prevention assemblies.
2. ASTM B209.

C. SECTIONALIZED ALUMINUM ENCLOSURES

1. Enclosure shall be a sectional prefabricated design with tongue and groove sections that slide together for fast and simple installation and shall be easily removable for equipment replacement.
2. Access panels have a four point locking system with pad lockable handle and are completely removable.
3. Drain ports are sized for full port backflow discharge and are designed for a one way operation allowing backflow discharge but not allowing wind, debris and small animals to enter the enclosure.
4. Standard enclosures shall be designed to support a minimum vertical load of 100lb/sf. E. Standard enclosures up to 36"W x 105"L x 64"H shall be designed to support wind speeds up to 120mph, all larger sizes shall be designed to support wind speeds up to 80mph.
5. Standard enclosures are ASSE 1060 certified.
6. Custom enclosures are designed and constructed in the same manner as standard certified enclosures, but have not been lab tested and listed by ASSE.

D. MATERIALS OF FABRICATION

1. Aluminum sheeting shall be 3003 aluminum (.051"/16 gauge), stucco embossed finish and shall meet ASTM B209. Stucco embossed finish reduces the glare and helps hide any surface scratches or imperfections received in the field.
2. Bracing shall be 6063-T52 aluminum and shall meet ASTM B221.
3. No wood or particle board to be used in the construction.
4. Anchor pads (galvanized steel) with 3/8-16 unc x 2 long zinc plated wedge anchors and drill bit are to be supplied.

5. Insulation shall be approximately 1.5" unicellular, non-wicking, polyisocyanate foam sprayed in place that forms a monolithic bond between the aluminum bracing and aluminum sheeting.
 6. The Insulation shall have the following properties:
 - a. R-Value: 10
 - b. Dimensional Stability: less than 2% linear change
 - c. Compressive Strength: 51psi
 - d. Flame point: 325 degrees
 - e. Water absorption: .037psf
 - f. Porosity: 91%
- E. HEATING EQUIPMENT (ASSE 1060 Class I-Required; ASSE 1060 Class II-Optional)
1. Heating equipment shall protect the piping and equipment from exterior temperatures to -30°F. ETL listed thermostatically controlled wall mounted air forced heaters shall be furnished and designed by the enclosure manufacturer to maintain the equipment at +40°F, in accordance with ASSE 1060 1.2.2.1.
 2. Heating equipment shall be wall mounted to the supplied heater plates and a minimum of 8" above the slab unless it is UL or ETL certified and NEC approved for submersion.
 3. Power source shall be protected with a GFI receptacle, U.L. 943, NEMA.3R. Mounted a minimum of 8" from the bottom of the receptacle to the top of the slab.
 4. Separate 20 amp circuits are recommended for each heater, so in the event a circuit fails all other circuits will remain powered. Installations must be in accordance with the local and national codes.
 5. The heaters shall be ETL listed for wet/damp locations.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas for compliance with requirements for installation tolerances and other conditions affecting performance of fuel-oil pumps and fuel-oil polishing system.

- B. Examine areas for compliance with requirements for installation tolerances and other conditions affecting performance of fuel-oil pumps and fuel-oil polishing system.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EARTHWORK

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

3.3 PREPARATION

- A. Close equipment shutoff valves before turning off fuel oil to premises or piping section.
- B. Comply with NFPA 30 and NFPA 31 requirements for prevention of accidental ignition.

3.4 INSTALLATION OF FUEL-OIL PUMPS

- A. Duplex pumps:
 - 1. Install pumps with access space for periodic maintenance including removal of motors, impellers, and accessories.
 - 2. Set pumps on and anchor to concrete base.
 - 3. Pump Mounting:
 - a. Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - b. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Install two-piece, full-port ball valves at suction and discharge of pumps. Comply with requirements in Section 232113 "HVAC Piping and Accessories."

- C. Install mechanical leak-detector valves at pump discharge.
- D. Install suction piping with minimum fittings and change of direction.
- E. Install vacuum and pressure gauge, upstream and downstream, respectively, at each pump to measure the differential pressure across the pump. Pressure gauges are specified in Section 230500 "Common Work Results for HVAC."

3.5 INSTALLATION OF FUEL-OIL POLISHING SYSTEMS

- A. Polishing System Mounting:
 - 1. Install equipment cabinet on cast-in-place concrete equipment base. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Install suction line, with foot valve, at one end of storage tank, 1 inch from the bottom of tank.
- C. Install return line at the opposite end of storage tank from suction line.

3.6 INSTALLATION OF HOT BOX

- A. The recommended slab size shall be 9" larger than the enclosures exterior dimensions and a minimum of 4" thick.
- B. The enclosure shall be assembled and mounted to concrete slab per the manufactures instructions provided with the enclosure.

3.7 LABELING AND IDENTIFYING

- A. Install nameplates and signs on each fuel-oil pump. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment."

3.8 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
 - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use supported equipment manufacturer's 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.
 - 6. Use 3000-psig, 28-day, compressive-strength concrete and reinforcement as specified in Section 033000 "Cast-in-Place Concrete."

3.9 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 supervise field tests and inspections.
- C. Tests and Inspections:
 - 1. Start fuel-oil transfer pumps and fuel-oil polishing system pump to verify for proper operation of pump, and check for leaks.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Fuel-oil pumps and fuel-oil polishing system will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.10 DEMONSTRATION

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

END OF SECTION

SECTION 23 13 13

FACILITY UNDERGROUND FUEL-OIL STORAGE TANKS

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Underground fuel-oil storage tanks, double-wall FRP.
2. Underground fuel-oil storage tank accessories.
3. Fuel-oil leak-detection and monitoring system.
4. Fuel-oil.
5. Labels and identification.
6. Source quality control.

B. Related Requirements:

1. Section 23 11 13 "Facility Fuel-Oil Piping."
2. Section 23 12 13 "Facility Fuel-Oil Pumps."

1.2 DEFINITIONS

A. FPM: Vinylidene fluoride-hexafluoropropylene copolymer rubber.

B. FRP: Glass-fiber-reinforced plastic.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, and dimensions of individual components and profiles.
 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 3. Fuel-oil storage tank accessories.
 4. Fuel-oil leak-detection and monitoring system.
- B. Shop Drawings: For underground fuel-oil storage tanks.
1. Include plans, elevations, sections, concrete ballast pads and anchors, and lifting or supporting points.
 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. Shop Drawing Scale: **1/4 inch per foot (1:50)**.

1.4 INFORMATIONAL SUBMITTALS

- A. Site Survey: Plans, drawn to scale, on which underground fuel-oil storage tanks are indicated and coordinated with other services and utilities.
- B. Field quality-control reports.
- C. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuel-oil equipment and accessories.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: For FRP tanks, installers are to be trained and certified by tank manufacturer.
- B. EPA Compliance: Comply with requirements of the EPA and of state and local authorities having jurisdiction.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Lift and support fuel-oil storage tanks only at designated lifting or supporting points, as indicated on Shop Drawings. Do not move or lift tanks unless empty.

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of fuel-oil storage tanks that fail in materials or workmanship within specified warranty period.

- 1. Storage Tanks:

- a. Failures include, but are not limited to, the following when used for storage of fuel oil at temperatures not exceeding 150 deg F:
 - 1) Structural failures including cracking, breakup, and collapse.
 - b. Warranty Period: 30 years from date of shipment.

PART 2 - PRODUCTS

2.1 UNDERGROUND FUEL-OIL STORAGE TANKS, DOUBLE-WALL FRP

- 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. Containment Solutions, Inc.
 - 2. Xeres
 - 3. Nationwide Tanks
- B. Description: Horizontal, 6,000 Gallon, FRP UST; UL 1316, double wall, with interstitial space and integral hydrostatic leak-detection and monitoring system.
- C. Construction: Fabricated with fiberglass-reinforced polyester resins; suitable for operation at atmospheric pressure; compatible with B5 Biodiesel Grade. No. 2 and

other liquids identified in the manufacturer's standard limited warranty; fabricated for the following loads:

1. Depth of Bury: 48 inches from top of tank to finished surface.
2. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.
3. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of 32,000 lb.

2.2 UNDERGROUND FUEL-OIL STORAGE TANK ACCESSORIES

- A. Tank Manholes: 22-inch-minimum diameter; bolted, flanged, and gasketed, with extension collar; for access to inside of tank.
 1. Composite Cover and Steel Frame: Lightweight, slip resistant, composite manhole covers, UV resistant, water resistant cam locks, 10" high frame, similar to EMCO model A0716.
- B. Threaded pipe connection fittings on top of tank for fill, supply, return, vent, sounding, and gaging; in locations and of sizes indicated. Include cast-iron plugs for shipping.
- C. Striker Plates: Inside tank, on bottom below fill, vent, sounding, gage, and other tube openings.
- D. Lifting Lugs: For handling and installation.
- E. Supply Tube: Extension of supply piping fitting into tank, terminating 6 inches above tank bottom and cut at a 45-degree angle.
- F. Sounding and Gage Tubes: Extension of fitting into tank, terminating 6 inches above tank bottom and cut at a 45-degree angle.
- G. Containment Sumps: Fiberglass with sump base, add-on extension pieces as required, sump top, lid, and gasket-seal joints. Include sump entry boots for pipe penetrations through sidewalls.
- H. Sump Entry Boots: Two-part pipe fitting for field assembly and of size required to fit over pipe. Include gaskets shaped to fit sump sidewall, sleeves, seals, and clamps as required for liquid-tight pipe penetrations.

- I. Anchor Straps: Storage tank manufacturer's standard anchoring system, with straps, strap-insulating material, cables, and turnbuckles; designed for a maximum strength at least one and one-half times maximum uplift force of empty tank without backfill in place.
- J. Overfill Prevention Valves: Factory fabricated or shop or field assembled from manufacturer's standard components. Include drop tube, cap, fill nozzle adaptor, check valve mechanism or other devices, and vent if required to restrict flow at 95 percent of tank capacity and to provide complete shutoff of filling at 98 percent of tank capacity.
- K. Spill-Containment Fill Boxes: For In-Ground Applications
 - 1. 15-gallon containment.
 - 2. Composite cover with load rating of C250 (25 tons).
 - 3. Tapered perimeter seal.
 - 4. Hand pump.
 - 5. Overfill alarm with digital readout, alarm light, alarm horn, and silence pushbutton.
 - 6. Leak detection.
- L. Venting: Underground tank shall be vented up to atmospheric pressure.

2.3 FUEL-OIL LEAK-DETECTION AND MONITORING SYSTEM

- A. Sensor System: Comply with UL 1238 and NEMA 12 standards. Hydrostatic System: Comply with UL 1238.
 - 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. Veeder-Root
 - b. Pneumercator
 - c. Omntec
 - d. Or approved equal.
 - 2. Source Limitations: Obtain fuel-oil leak-detection and monitoring system from single manufacturer.

3. For Sensor System: Calibrated fuel-oil leak-detection and monitoring system with probes and other sensors and remote alarm panel for fuel-oil storage tank, and fuel-oil piping. For Hydrostatic System: Calibrated fuel-oil leak-detection and monitoring system with brine antifreeze solution, reservoir sensor, and electronic control panel to monitor leaks in inner and outer tank walls.
4. Include fittings and devices required for testing.
5. Controls: Electrical, operating on 120-V ac.
6. Calibrated fuel-oil-level gauges complying with UL 180 with floats or other sensors and remote annunciator panel.
7. Remote annunciator panel with visual and audible, level alarms, fuel indicator with registration in gallons, overfill alarm, and interstitial leak. Include gauge volume range that covers fuel-oil storage capacity.
 - a. Fuel level alarms to include:
 - 1) Critical low level.
 - 2) Low level.
 - 3) High level.
 - 4) High-high level.
8. Remote Annunciator Panel Controls: Electrical, operating on 120-V ac.
9. Common alarm outputs to interface with the BMS per section 230900 "Building Management System". Refer to fuel oil system controls detail for outputs required.
10. Provide with software updates and necessary connectors and accessories for submersible pump control and monitoring.

2.4 FUEL OIL

- A. Diesel Fuel Oil: ASTM D 975, B5 Biodiesel Grade. No. 2.

2.5 LABELS AND IDENTIFICATION

- A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (152 mm) wide and 4 mils (0.1 mm) 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 (762 mm) deep; colored yellow.

2.6 SOURCE QUALITY CONTROL

- A. Pressure test and inspect fuel-oil storage tanks, after fabrication and before shipment, according to ASME and the following:
 - 1. FRP USTs: UL 1316.
- B. Affix standards organization's code stamp.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for underground fuel-oil storage tanks to verify actual locations.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EARTHWORK

- A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.
- B. Excavate to sufficient depth for a minimum of 36 inches (900 mm) of earth cover from top of tank to finished grade. Allow for cast-in-place, concrete-ballast base plus 6 inches (150 mm) of sand or pea gravel between ballast base and tank. Extend excavation at least 12 inches (300 mm) around perimeter of tank.
- C. Backfill excavation with clean sand or pea gravel in 12-inch (305-mm) lifts and tamp backfill lift to consolidate.
- D. Install filter mat between top of backfill material and earth fill.

3.3 INSTALLATION OF UNDERGROUND FUEL-OIL STORAGE TANK

- A. Install tank in accordance with NFPA 30 and 31 by a contractor trained and certified by tank manufacturer.
- B. Set tie-down eyelets for hold-down straps in concrete-ballast base and tie to reinforcing steel.
- C. Place 6 inches (152 mm) of clean sand or pea gravel on top of concrete-ballast base.
- D. Set tank on fill materials and install hold-down straps.
- E. Connect piping.
- F. Install tank leak-detection and monitoring devices.
- G. Install containment sumps.
- H. Install FRP underground fuel-oil storage tank with FRP hold-down straps, manhole extensions, and manhole risers.
- I. Fill storage tank with specified fuel oil.

3.4 INSTALLATION OF LIQUID-LEVEL GAUGE SYSTEM

- A. Install liquid-level gauge system. Install panel inside building at location indicated on Drawings.

3.5 INSTALLATION OF FUEL-OIL LEAK-DETECTION AND MONITORING SYSTEM

- A. Install fuel-oil leak-detection and monitoring system. Install alarm panel inside building at location indicated.

1. Double-Wall, Fuel-Oil Storage Tanks: Install probes or use factory-installed integral probes in interstitial space.
2. Double-Containment, Fuel-Oil Piping: Install leak-detection sensor probes in fuel-oil storage tank containment sumps and at low points in piping.
3. Install liquid-level gage.

3.6 LABELING AND IDENTIFYING

- A. Nameplates, pipe identification, and signs are specified in Section 230553 "Identification for HVAC Piping and Equipment."
- B. Install detectable warning tape directly above UST, 12 inches below finished grade, except 6below subgrade under pavements and slabs.
 1. Terminate tracer wire in an accessible area and identify as "tracer wire" for future use with plastic-laminate sign.
 2. Install over edges of each UST.

3.7 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base or anchor system in accordance with manufacturer's written instructions and according to seismic codes at Project.
 1. Tanks: Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 4. Place and secure anchorage devices. Use supported equipment manufacturer's 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.
 6. Use 3000-psig, 28-day, compressive-strength concrete and reinforcement as specified in Section 033000 "Cast-in-Place Concrete."

3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Tanks: Minimum hydrostatic or compressed-air test pressures for fuel-oil storage tanks that have not been factory tested and do not bear the ASME code stamp or a listing mark acceptable to authorities having jurisdiction:
 - a. Double-Wall Tanks:
 - 1) Inner Tanks: Minimum 3 psig and maximum 5 psig
 - 2) Interstitial Space: Minimum 3 psig and maximum 5 psig, or 5.3-in. Hg vacuum.
 - b. Where vertical height of fill and vent pipes is such that the static head imposed on the bottom of the tank is greater than 10 psig, hydrostatically test the tank and fill and vent pipes to a pressure equal to the static head thus imposed.
 - c. Maintain the test pressure for one hour.
- B. USTs will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 231313

SECTION 23 21 13

HYDRONIC PIPING

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Plastic pipe and fittings.
3. Piping joining materials.
4. Transition fittings.

ACTION SUBMITTALS

B. Product Data: For each type of product.

C. Delegated Design Submittals:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors, alignment guides, and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.2 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Piping layout, or BIM model, drawn to scale, indicating the items described in this Section, and coordinated with all building trades.
- B. Qualification Data: For Installer.
- C. Welding certificates.

1.3 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Installers of Pressure-Sealed Joints: Installers are to be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
 - 2. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP are to be certified by manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.
- B. Steel Support Welding: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M.
- C. Pipe Welding: Qualify procedures and operators in accordance with ASME Boiler and Pressure Vessel Code: Section IX.
 - 1. Comply with ASME B31.9 for materials, products, and installation.
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

1.4 WARRANTY

- A. PP-R and PP-RCT Manufacturer's Warranty: Manufacturer agrees to repair or replace PP-R and PP-RCT pipe and fittings that fail in materials or workmanship within 10 years from date of Substantial Completion.
 - 1. Warranty is to cover labor and material costs of repairing and/or replacing defective materials and repairing any incidental damage caused by failure of the piping system due to defects in materials or manufacturing.
 - 2. Warranty is to be in effect only upon submission by Contractor to manufacturer of valid pressure/leak documentation indicating that the system

was tested and passed manufacturer's pressure/leak test and any other manufacturer requirements.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation are to be capable of withstanding the following minimum working pressures and temperatures unless otherwise indicated:
1. Hot-Water Heating Piping: **100 psig (689 kPa) at 200 deg F (93 deg C).**
 2. Condensate-Drain Piping: **150 deg F (66 deg C)**
 3. Air-Vent Piping: **200 deg F (93 deg C)**
 4. Pressure-Relief-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tube: **ASTM B88, Type K (ASTM B88M, Type A)**
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cambridge-Lee Industries, LLC.
 - b. Cerro Flow Products, LLC.
 - c. Mueller Streamline Co.; a company of Mueller Industries.
- B. Wrought-Copper, Solder-Joint Fittings: ASME B16.22 pressure fittings. Do not use solder joints on pipe sizes greater than NPS 4 (DN 100).
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Elkhart Products Corporation; a part of Aalberts Integrated Piping Systems.
 - b. Mueller Streamline Co.; a company of Mueller Industries.
 - c. NIBCO INC.
- C. Wrought-Copper Unions: ASME B16.22. Do not use solder joints on pipe sizes greater than NPS 4 (DN 100).
- D. Copper-Tube, Pressure-Seal-Joint Fittings - Copper or Bronze:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Mueller Streamline Co.; a company of Mueller Industries.
 - c. NIBCO INC.
 - d. Victaulic Company.
 - e. Viega LLC.
2. Source Limitations: Obtain copper-tube pressure-seal-joint fittings from single manufacturer.
3. Housing: Copper or bronze.
4. O-Rings and Pipe Stops: EPDM.
5. Tools: Manufacturer's special tools.
6. Minimum 200 psig (1370 kPa) working pressure rating at 250 deg F (121 deg C).

2.3 PLASTIC PIPE AND FITTINGS

- A. PVC Plastic Pipe: ASTM D1785, with wall thickness as indicated in "Piping Applications" Article.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Charlotte Pipe and Foundry Company.
 - b. IPEX USA LLC.
 - c. Spears Manufacturing Company.
 2. Source Limitations: Obtain PVC plastic pipe from single manufacturer.
 3. PVC Socket Fittings: **ASTM D2466 for Schedule 40**
 4. PVC Schedule 80 Threaded Fittings: ASTM D2464.
- B. Smoke and Fire Ratings:
 1. Where indicated on Drawings that a plenum-rated piping system is required, the pipe is to be wrapped and/or insulated with fiberglass or mineral wool pipe insulation; field installed.
 - a. The system is to have a flame-spread classification of less than 25 and smoke-developed rating of less than 50.
 - b. Pipe, wrap, or insulation as a system to comply with the requirements of CAN/ULC-S102.2, ASTM E84, or UL 2846.
 - c. For insulation required for thermal and condensation conditions, see Section 230719 "HVAC Piping Insulation."

2.4 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless otherwise indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.
- D. Solder Filler Metals: ASTM B32, lead-free alloys.
- E. Flux: ASTM B813, water flushable.
- F. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
- G. 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.

2.5 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.
- C. Plastic-to-Metal Transition Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. IPEX USA LLC.
 - b. Uponor Inc.
 - c. Viega LLC.
 2. Source Limitations: Obtain plastic-to-metal transition fittings from single manufacturer.
 3. Description:
 - a. PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions.
 - b. One end with threaded brass insert and one solvent-cement-socket or threaded end.
 4. One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.
- D. Plastic-to-Metal Transition Unions:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. IPEX USA LLC.
 - b. NIBCO INC.
 - c. aquatherm.
 2. Source Limitations: Obtain plastic-to-metal transition unions from single manufacturer.
 3. Brass or copper end and solvent-cement-joint end of union to match pipe in size and material.
 4. Description:
 - a. PVC four-part union.
 - b. Brass threaded end.
 - c. Solvent-cement-joint or threaded plastic end.
 - d. Rubber O-ring.
 - e. Union nut.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Hot-Water Heating Piping, Aboveground, NPS 2 (DN 50) and Smaller, to Be Any of the Following:
 - 1. **Type L (Type B)** drawn-temper copper tubing, wrought-copper fittings, and **pressure-seal** joints.
- B. Condensate-Drain Piping Installed Aboveground to Be Any of the Following:
 - 1. **Schedule 40**, PVC plastic pipe and fittings and solvent-welded joints.
- C. Air-Vent Piping:
 - 1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems, according to piping manufacturer's written instructions.
 - 2. Outlet: Type K (Type A), annealed-temper copper tubing with soldered or flared joints.
- D. Pressure-Relief-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed, with metal-to-plastic transition fittings for plastic piping systems, according to piping manufacturer's written instructions.

3.2 INSTALLATION OF PIPING

- A. 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.
- 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. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- O. Install branch connections to mains using **mechanically formed** tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- P. Install valves according to Section 230523 "General-Duty Valves for HVAC Piping."
- Q. Install air vents and pressure-relief valves in accordance with Section 232116 "Hydronic Piping Specialties."
- R. Install unions in piping, **NPS 2 (DN 50)** and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- S. Install flanges in piping, **NPS 2-1/2 (DN 65)** and larger, at final connections of equipment and elsewhere as indicated.
- T. Install shutoff valve immediately upstream of each dielectric fitting.

- U. Comply with requirements in Section 230500 "Common Work Results for HVAC" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.
- V. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.
- W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230500 "Common Work Results for HVAC."
- X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230500 "Common Work Results for HVAC."
- Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230500 "Common Work Results for HVAC."

3.3 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. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints in accordance with ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.
- D. Brazed Joints: Construct joints in accordance with AWS's "Brazing Handbook," "Pipe and Tube" chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.
- E. Threaded Joints: Thread pipe with tapered pipe threads in accordance with 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.
- F. Welded Joints: Construct joints in accordance with AWS D10.12M/D10.12, using qualified processes and welding operators in accordance with "Quality Assurance" Article.
- G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- H. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings in accordance with the following:
 1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
 2. CPVC Piping: Join in accordance with ASTM D2846/D2846M Appendix.
 3. PVC Pressure Piping: Join ASTM D1785 schedule number, PVC pipe, and PVC socket fittings in accordance with ASTM D2672. Join other-than-schedule-number PVC pipe and socket fittings in accordance with ASTM D2855.
 4. PVC Nonpressure Piping: Join in accordance with ASTM D2855.
- I. Pressure-Seal Joints: Use manufacturer-recommended tools and procedure. Leave insertion marks on pipe after assembly.

3.4 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.
- C. Install hangers for **copper tubing**, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- D. Install hangers for plastic piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

- E. Install hangers for fiberglass piping, with maximum horizontal spacing and minimum rod diameters, to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- F. Support horizontal piping within **12 inches (300 mm)** of each fitting and coupling.
- G. Support vertical runs of **copper tubing** to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- H. Support vertical runs of **PVC** piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- I. Support vertical runs of fiberglass piping to comply with manufacturer's written instructions, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.5 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections are to be the same as or larger than equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
- D. Install ports for pressure gauges and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230500 "Common Work Results for HVAC."

3.6 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification materials and installation in Section 230553 "Identification for HVAC Piping and Equipment."

3.7 SYSTEM STARTUP

- A. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

3.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping in accordance with ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure is to be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install pressure-relief valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient-temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure is not to exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9.

5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

END OF SECTION 232113

SECTION 23 21 13.13

UNDERGROUND PIPING

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. PEX tube and fittings.
2. Preengineered cased piping system.
3. Loose-fill insulation.

1.2 DEFINITIONS

- A. Invert:** Vertical distance from Project datum reference point to bottom interior pipe surface.
- B. Reinforced, Thermosetting Resin Fitting (RTRF):** Fittings fabricated of composite materials, largely consisting of a reinforcement material embedded in, or surrounded by, cured thermosetting resin. Most common form of reinforced, thermosetting resin pipe is one in which fiberglass strands form reinforcement.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Preengineered conduit piping system components.
2. Preengineered cased piping system components.
3. Cased piping.
4. Loose-fill insulation.

- B. Shop Drawings: For underground hydronic piping. Signed and sealed by a professional engineer.
 - 1. Include calculations showing requirements for expansion compensation for underground piping.
 - 2. Show expansion compensators, offsets, and loops with appropriate materials to allow piping movement at required locations. Show anchors and guides that restrain piping movement with calculated loads, and show concrete thrust block dimensions.
 - 3. Show pipe sizes, locations, inverts, and pitch. Show piping in trench, piping in conduit, and cased pipe with details showing clearances between piping.
 - 4. Show insulation thickness.
- C. Delegated Design Submittal: For underground hydronic piping systems indicated to comply with performance requirements and design criteria, including analysis data and design drawings signed and sealed by the professional engineer responsible for their preparation.
 - 1. Include design calculations and details for selecting thermal expansion and thrust restraints.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from hydronic distribution piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.
- B. Profile Drawings: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet (1:500) and at vertical scale of not less than 1 inch equals 5 feet (1:50).
 - 1. Show locations and inverts of utility system manholes and piping. Show manholes and piping. Show types, sizes, materials, and inverts of other utilities crossing hydronic piping.
 - 2. Show depth of cover from top of hydronic system pipes to finished grade.
- C. Qualification Data: For Installer.
- D. Welding certificates.
- E. Material Test Reports: For **cased** piping, by a qualified testing agency.

F. Source quality-control reports.

G. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Fiberglass Pipe and Fitting Installers: Provide RTRF and RTRP pipe installation by technicians certified by manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesives and methods.

B. Welding Qualifications: Qualify procedures and personnel in accordance with ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with provisions in ASME B31.9, "Building Services Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

1.6 FIELD CONDITIONS

A. Interruption of Existing Utilities: Do not interrupt utilities serving occupied facilities unless permitted under the following conditions and then only after arranging to provide temporary utility services in accordance with requirements indicated:

1. Notify **Architect** no fewer than **two** days in advance of proposed interruption of utility.
2. Do not proceed with interruption of utility without **Architect's** written permission.

1.7 COORDINATION

A. Coordinate pipe-fitting pressure classes with products specified in related Sections.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing hydronic piping systems with the following minimum working-pressure ratings:
 - 1. Hot-Water Piping: **100 psig (690 kPa) at 200 deg F (93 deg C).**
- B. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design underground hydronic piping systems, including restraints and anchors.

2.2 PEX TUBE AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - 2. IPEX USA LLC.
 - 3. MrPex Systems Inc.
 - 4. REHAU.
- B. Source Limitations: Obtain PEX tube and fittings from single source from single manufacturer.
- C. Pipe Material: PEX plastic in accordance with ASTM F876.
- D. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) in accordance with DIN 4726.
- E. Fittings:
 - 1. **ASTM F1807, metal insert and copper crimp rings.**
 - 2. Factory-fabricated elbows and tees with manufacturer-furnished fitting insulation kit. Provide fittings recommended by and compatible with carrier pipe.
- F. Pressure/Temperature Rating: Minimum 100 psig (690 kPa) and 180 deg F (82 deg C).

- G. Insulation: **PEX foam** filling annular space between PEX tubing and jacket; thickness indicated in "Piping Application" Article.
- H. Jacket: Corrugated HDPE.

2.3 PREENGINEERED CASSED PIPING SYSTEM

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. PermAlert.
 - 2. REHAU.
 - 3. Thermal Pipe Systems.
 - 4. Uponor Inc.
- B. Source Limitations: Obtain piping system from single source from single manufacturer.
- C. Description: Factory-fabricated piping with carrier pipe, insulation, and casing.
- D. Carrier Pipe: Materials as indicated in "Piping Application" Article. See articles in this Section for required carrier pipe material characteristics.
- E. Carrier Pipe Insulation:
 - 1. Polyurethane Foam Pipe Insulation: Rigid, cellular, and high-pressure injected between carrier pipe and jacket.
 - a. Comply with ASTM C591; thermal conductivity (k-value) may not exceed 0.165 Btu x in./h x sq. ft. x deg F (0.024 W/m x K) at 75 deg F (24 deg C) after 180 days of aging.
- F. Casing: **HDPE**.
- G. Casing accessories include the following:
 - 1. Joint Kit: Half-shell, pourable or split insulation, casing sleeve, and shrink-wrap sleeve.
 - 2. Expansion Blanket: Elastomeric foam, formed to fit over piping.
 - 3. End Seals: Shrink wrap the casing material to seal watertight around casing and carrier pipe.

- H. Manholes: Black steel with lifting eyes.
 - 1. Finish: Spray-applied urethane, minimum 30 mils (0.75 mm) thick.
 - 2. Access: 30-inch- (750-mm-) diameter waterproof cover with gasket, ladder, and two 6-inch (150-mm) vents, one high and one low, extending above grade with rain caps.
 - 3. Conduit Stub-Outs and Seals: Welded steel with drain and vent openings.
 - 4. Sump: 12 inches (300 mm) in diameter; 12 inches (300 mm) deep.
 - 5. Floatation Anchor: Oversized bottom keyed into concrete base.
- I. Cover: With polyurethane foam insulation with an HDPE jacket; thickness indicated in "Piping Application" Article.
- J. Source Quality Control: Factory test carrier pipe to 150 percent of operating pressure of system. Furnish test certificates.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. See Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATION

- A. Hot-Water Heating Piping:
 - 1. **NPS 2 (DN 50) and smaller** to be **any of** the following:
 - a. PEX tube and fittings.
- B. Refrigerant Piping
 - 1. Cased Piping: Polyurethane carrier-pipe insulation.
 - a. Piping Insulation Thickness: 2 inches (50 mm)

3.3 INSTALLATION OF PIPING

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such 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. Remove standing water in the bottom of trench.
- C. Bed the pipe on a minimum 6-inch (150-mm) layer of pipe system manufacturer's recommended granular fill material with a minimum 6-inch (150-mm) clearance between pipes.
- D. Do not backfill piping trench until field quality-control testing has been completed and results approved.
- E. Install piping at uniform grade of 0.2 percent. Install required fittings to accommodate capped drains at low points and elsewhere as required for system drainage. Install capped manual air vents at high points.
 - 1. Maintain continuous bedding under piping. Do not leave gaps in pipe bedding, allowing pipe to sag between contact points with the bedding.
- F. In conduits, install drain valves at low points and manual air vents at high points.
- G. Install components with pressure rating equal to or greater than system operating pressure.
- H. Install piping in straight lines. Do not bend pipe.
- I. Install fittings for changes in direction and branch connections.
- J. See Section 230500 "Common Work Results for HVAC" for sleeves and mechanical sleeve seals through exterior building walls.
- K. Secure anchors with concrete thrust blocks. Concrete is specified in Section 033000 "Cast-in-Place Concrete."
- L. Connect to hydronic piping where it passes through the building wall. Hydronic piping inside the building is specified in Section 232113 "Hydronic Piping."
- M. See Section 230523 "General-Duty Valves for HVAC Piping" for sleeves and mechanical sleeve seals through exterior building walls.
- N. Secure anchors and fittings where piping changes direction, and where elsewhere required by manufacturer's written installation instructions, with concrete thrust blocks. Concrete is specified in Section 033000 "Cast-in-Place Concrete."

- O. See Section 134713 "Cathodic Protection" for cathodic devices and connections to piping and conduit systems.
- P. Apply bitumastic coating to carbon-steel anchors and guides. Pour concrete thrust blocks and anchors. See Section 033000 "Cast-in-Place Concrete" for concrete and reinforcement.
- Q. After field quality-control testing is complete, backfill with 6 inches (150 mm) of clean, granular material in accordance with piping system manufacturer's written instructions. If mechanical compaction is required, manually backfill to 12 inches (300 mm) before using mechanical-compaction equipment.

3.4 JOINT CONSTRUCTION

- A. See Section 330500 "Common Work Results for Utilities" for basic piping joint construction.
- B. Join pipe and fittings in accordance with the following requirements and Section 232113 "Hydronic Piping":
 - 1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
 - 2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints in accordance with ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.
- D. Brazed Joints: Construct joints in accordance with AWS's "Brazing Handbook," Ch. 35, "Pipe and Tubing," using copper-phosphorus brazing filler metal complying with AWS A5.8M/A5.8.
- E. Threaded Joints: Thread pipe with tapered pipe threads in accordance with ASME B1.20.1 or ISO 7-1. 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.
- F. Welded Joints: Construct joints in accordance with AWS D10.12M/D10.12, using qualified processes and welding operators, in accordance with "Quality Assurance" Article.
- G. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.
- H. Conduit and Cased Piping Joints: Assemble sections and finish joints with pourable or split insulation and exterior jacket sleeve, and apply shrink-wrap seals.

3.5 IDENTIFICATION

- A. Install continuous plastic underground warning tapes during backfilling of trenches for underground hydronic piping. Locate tapes 6 to 8 inches (150 to 200 mm) below finished grade, directly over piping. See Section 312000 "Earth Moving" for warning-tape materials and devices and their installation.

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. Prepare hydronic piping for testing in accordance with ASME B31.9 and as follows:
 - a. Leave joints, including welds, uninsulated and exposed for examination during test.
 - b. Isolate equipment and instrumentation. Do not subject equipment and instrumentation to test pressure.

- c. Install relief valve set to relieve at pressure no more than one-third higher than test pressure.
 - d. Fill system with water. Where there is risk of freezing, perform testing with air or liquid that will not freeze or cause damage to piping system materials.
 - e. For hydrostatic testing, install vents at high points to release trapped air while filling system. Remove test liquid at accessible low points.
- 2. Test hydronic piping as follows:
 - a. Subject hydronic piping to hydrostatic test pressure that is not less than 1.5 times system design pressure.
 - b. After hydrostatic test pressure has been applied for 10 minutes, examine joints for leakage. Remake leaking joints using new materials and repeat hydrostatic test until no leaks exist.
 - c. Do not pressurize carrier pipe with air.
 - d. Maintain test pressure for two hours with no loss of pressure.
- 3. Test conduit as follows:
 - a. Seal vents and drains and subject conduit to 15-psig (105-kPa) compressed air for four hours with no loss of pressure. Repair leaks and retest.
- E. Piping will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.
- G. When successful testing is complete, flush carrier piping to remove dirt or debris remaining after construction. Drain piping after flushing is complete.
- H. Fill underground piping system with permanent system liquid prior to system testing and balancing.

END OF SECTION

SECTION 23 21 16

HYDRONIC PIPING SPECIALTIES

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hydronic specialty valves.
2. Air vents.
3. Expansion tanks and fittings.
4. Air/dirt separators and purgers.
5. Strainers.
6. Flexible connectors.

B. Related Requirements:

1. Section 230500 "Common Work Results for HVAC" for expansion fittings and loops.
2. Section 230523 "General-Duty Valves for HVAC Piping" for specification and installation requirements for general-duty valves common to most piping systems.
3. Section 230923.11 "Control Valves" for automatic control valve and sensor specifications, installation requirements, and locations.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product:

1. Include construction details and material descriptions for hydronic piping specialties.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.

3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For hydronic piping specialties to include in emergency, operation, and maintenance manuals.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.5 QUALITY ASSURANCE

- A. Pipe Welding: Qualify procedures and operators in accordance with ASME BPVC, Section IX.
- B. Pressure-relief and safety-relief valves and pressure vessels bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME BPVC, Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

- A. Bronze, Calibrated-Orifice, Balancing Valves:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Armstrong Fluid Technology.
 - c. Bell & Gossett; a Xylem brand.
 - d. Flamco; a division of AALBERTS Ind.
 - e. Griswold Controls, LLC.
 - f. HCI; Hydronics Components Inc.
 2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
 3. Ball: Brass or stainless steel.
 4. Plug: Resin.

5. Seat: PTFE.
 6. End Connections: Threaded or socket.
 7. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
 8. Handle Style: Lever, with memory stop to retain set position.
 9. CWP Rating: Minimum 125 psig (860 kPa).
 10. Maximum Operating Temperature: 250 deg F (121 deg C).
- B. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Bell & Gossett; a Xylem brand.
 - c. Keckley Company.
 - d. NIBCO INC.
 - e. Taco Comfort Solutions.
 - f. Victaulic Company.
 - g. WATTS; A Watts Water Technologies Company.
 2. Body: Bronze or brass.
 3. Disc: **EPDM**.
 4. Seat: **Brass**.
 5. Stem Seals: EPDM O-rings.
 6. Diaphragm: EPDM.
 7. Low inlet-pressure check valve.
 8. Inlet Strainer: Bronze or stainless steel mesh, removable without system shutdown.
 9. Valve Seat and Stem: Noncorrosive.
 10. Valve Size and Capacity: As indicated on Drawings.
 11. Operating Pressure: Factory set and field adjustable.
- C. Diaphragm-Operated Pressure-Relief Valves: ASME labeled.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Bell & Gossett; a Xylem brand.
 - c. Keckley Company.
 - d. WATTS; A Watts Water Technologies Company.
 2. Body: Bronze or brass.
 3. Disc: **Brass**.
 4. Seat: **Brass**.
 5. Stem Seals: EPDM O-rings.
 6. Diaphragm: EPDM.
 7. Valve Seat and Stem: Noncorrosive.

8. Valve Size, Capacity, and Operating Pressure: Comply with ASME BPVC, Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

D. Automatic Flow-Control Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Bell & Gossett; a Xylem brand.
 - c. Flowcon Americas LLC.
 - d. HCI; Hydronics Components Inc.
2. Body: Brass or ferrous metal.
3. Combination Assemblies: Include bronze or brass-alloy ball valve.
4. Identification Tag: Marked with zone identification, valve number, and flow rate.
5. Size and Capacity: For each application, provide a valve with rated capacity equal to or greater than capacity of device being served.
6. Performance: Maintain constant flow within plus or minus 10 percent, regardless of system pressure fluctuations.
7. Minimum CWP Rating: **175 psig (1207 kPa).**
8. Maximum Operating Temperature: **200 deg F (93 deg C).**

2.2 AIR VENTS

A. Manual Air Vents:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Bell & Gossett; a Xylem brand.
 - c. Nexus Valve, Inc.; Aalberts Hydronic Flow Control.
 - d. Taco Comfort Solutions.
 - e. WATTS; A Watts Water Technologies Company.
2. Body: Bronze.
3. Internal Parts: Nonferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2 (DN 15).
6. Discharge Connection: NPS 1/8 (DN 6).
7. CWP Rating: 150 psig (1035 kPa).
8. Maximum Operating Temperature: 225 deg F (107 deg C).

2.3 EXPANSION TANKS AND FITTINGS

A. Bladder-Type ASME Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong Fluid Technology.
 - b. Bell & Gossett; a Xylem brand.
 - c. Taco Comfort Solutions.
 - d. WATTS; A Watts Water Technologies Company.
2. Tank: Welded steel, rated for 125 psig (860 kPa) working pressure and 375 deg F (191 deg C) maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled in accordance with ASME BPVC, Section VIII, Division 1.
3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity. **Field-replaceable bladder.**
4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

2.4 AIR/DIRT SEPARATORS AND PURGERS

A. Coalescing-Type Air and Dirt Separators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong Fluid Technology.
 - b. Bell & Gossett; a Xylem brand.
 - c. Flamco; a division of AALBERTS Ind.
 - d. Nexus Valve, Inc.; Aalberts Hydronic Flow Control.
 - e. Taco Comfort Solutions.
2. Tank: Fabricated steel tank; ASME constructed and stamped for 125 psig (862 kPa) working pressure and 270 deg F (130 deg C) maximum operating temperature.
3. Coalescing Medium: **Stainless steel.**
4. Air Vent: Threaded to top of separator.
5. Inline Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; Class 150 flanged connections for NPS 2-1/2 (DN 65) and larger.
6. Blowdown Connection: Threaded to bottom of separator.
7. Size: Match system flow capacity.

2.5 STRAINERS

A. Y-Pattern Strainers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. FNW; Ferguson Enterprises, Inc.
 - c. Griswold Controls, LLC.

- d. Metraflex Company (The).
 - e. Nexus Valve, Inc.; Aalberts Hydronic Flow Control.
- 2. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
 - 3. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
 - 4. Strainer Screen: Stainless steel, **40**-mesh strainer, or perforated stainless steel basket.
 - 5. CWP Rating: 125 psig (860 kPa).

2.6 FLEXIBLE CONNECTORS

A. Stainless Steel Bellows, Flexible Connectors:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ASC Engineered Solutions.
 - b. Flexicraft Industries.
 - c. Flo Fab Inc.
 - d. Metraflex Company (The).
- 2. Body: Stainless steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
- 3. End Connections: Threaded or flanged to match equipment connected.
- 4. Performance: Capable of 3/4-inch (20-mm) misalignment.
- 5. CWP Rating: 150 psig (1035 kPa).
- 6. Maximum Operating Temperature: 250 deg F (121 deg C).

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine all piping specialties 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. Examine threads on all devices 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 piping specialties; replace with new devices. Remove defective piping specialties from site.

3.2 INSTALLATION OF VALVES

- A. Install calibrated-orifice balancing valve at each branch connection to return main.
- B. Install calibrated-orifice, balancing valve in the return pipe of each heating or cooling terminal.
- C. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.
- D. Install pressure-relief and safety-relief valves at hot-water generators and elsewhere as required by ASME BPVC. Pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME BPVC, Section VIII, Division 1, for installation requirements.

3.3 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install automatic air vents at high points of system piping in mechanical equipment rooms only.
 - 1. Provide air outlet drain line full size of air outlet to floor drain or to other point indicated on Drawings.
- C. Install manual vents at heat-transfer coils and elsewhere as required for air venting.
- D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 (DN 50) and larger.
- E. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve full size of separator outlet; extend full size to nearest floor drain.
- F. Install expansion tanks having direct air/water interface above the air separator or air purger. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

1. Install tank fittings that are shipped loose.
 2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, and fittings, plus tank full of water. Do not overload building components and structural members.
 3. Install piping from air separator or air purger to expansion tank with a 2 percent upward slope toward tank to avoid air entrapment.
- G. Install diaphragm- or bladder-type expansion tanks on the floor.
- H. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION

SECTION 23 21 23

HYDRONIC PUMPS

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Wet-rotor pumps.

1.2 DEFINITIONS

- A. ECM: Electronically commutated motor.
- B. EPDM: Ethylene propylene diene monomer.
- C. EPR: Ethylene propylene rubber.
- D. FKM: Fluoroelastomer polymer.
- E. HI: Hydraulic Institute.
- F. NBR: Nitrile rubber or Buna-N.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of pump.
 - 1. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated.
 - 2. Indicate pump's operating point on curves.

- B. Shop Drawings: For each pump.
 - 1. Show pump layout and connections.
 - 2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
 - 3. Include diagrams for power, signal, and control wiring.
- C. Delegated Design Submittals: For each pump.
 - 1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
 - a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - b. 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.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Seismic Qualification Data: Certificates for 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 pumps 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. Mechanical Seals: One mechanical seal(s) for each pump.

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. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation and seismic restraints.
- C. Seismic Performance: Pumps shall withstand the effects of earthquake motions determined in accordance with 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. Component Importance Factor: 1.5.
 - a. WET-ROTOR PUMPS
- D. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Armstrong Fluid Technology.
 - 2. Flowserve Corporation.
 - 3. GRUNDFOS CBS Inc.
 - 4. Bell & Gossett
- E. Source Limitations: Obtain pumps from single source from single manufacturer.
- F. Description: Factory-assembled and -tested, wet-rotor pump. Pump and motor to form an integral unit with bearings lubricated by the pumped liquid.

G. Pump Construction:

1. Body: Cast iron.
2. Impeller: Noryl.
3. Pump Shaft: Ceramic.
4. Bearings. Double-sintered carbon.

H. Motor:

1. Motor Type: High-efficiency, [Variable] speed, permanent magnet, electronically commutated (ECM) "wet-rotor" motor.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.
3. Motor Controls: Motor shall have integrated controls capable of multiple operating modes, including:
 - a. Constant Speed
 - b. Constant Pressure
 - c. Proportional Pressure
4. Motor Protection: Motor shall have built-in dry-run protection, thermal overload protection, and automatic air purging.
5. Communications: Unit shall be capable of 0-10 VDC or PWM analog control and MODBUS or BACnet digital communication.
 - a. If Project has more than one type or configuration of wet-rotor pump, delete "Capacities and Characteristics" Paragraph below and schedule pumps on Drawings.
 - b. INTEGRAL PUMP MOTOR VARIABLE-SPEED CONTROLLERS

I. Where specified or scheduled, provide pumps with an integral pump motor speed controller.

1. Motor: Operates as constant- or variable-speed pump with speed regulated by an integrated variable-speed drive.
2. Integrated Pump Controller: Supports direct communication with the building management system (BMS) with built-in support for the following protocols: BACnet™ MS/TP.
3. Commissioning and pump set up access to pump controls via the following:
 - a. A web interface (data exchange).
 - b. A user interface located on the face of speed controller to adjust modes and mode values.
 - c. An electronic display that reads real-time mode set values, flow, head, speed, and power and that locks out unauthorized adjustment of pump.
4. Provide electronics with "Auto" as factory default but slope of the proportional curve will automatically match the required system curve, constant pressure

control (delta-p/c), variable differential pressure control (delta-p/v), constant curve duty (uncontrolled pump), and rpm regulation. RPM (speed) regulation can be accomplished by the following:

- a. Manual (via user interface or HTML).
 - b. Remote via 0 to 10 V dc.
 - c. Data protocol communications with the BMS.
5. Pump Electronics: Standard with multiple digital inputs and one external digital output to be available for additional mechanical room control and pump status monitoring.
 6. Controller: Mounted on or adjacent to the motor. Provide enclosure rated to UL Type 12.
 7. Electronically Protected Pumps: Rated for continuous duty and with built-in startup circuit. Provide overcurrent, line surge and current limit protection, thermal monitoring, heat sink status and over temperature protection.
 8. Pump capable of being monitored continuously via integrated Internet link.
 9. Integrated pump controller system to have the following features:
 - a. Controller software shall be capable of sensorless control in variable-volume systems without need for pump-mounted (internal/external) or remotely mounted differential pressure sensor.
 - b. Integrated Pump Controller Sensorless Control: Operates under Quadratic Pressure Control (QPC) to ensure that head reduction with reducing flow conforms to quadratic control curve.
 - c. Controller:
 - 1) Minimum head of 40 percent of design duty head.
 - 2) User-adjustable control mode settings and minimum/maximum head set points using built-in programming interface.
 - d. Controller Integrated Control Software:
 - 1) Capable of controlling pump performance for non-overloading power at every point of operation.
 - 2) Capable of maintaining flow rate data.

2.2 ELECTRONICALLY COMMUTATED MOTOR (ECM)

A. Provide pumps so they are specified or scheduled with ECM.

1. Synchronous, constant torque, ECM with permanent magnet rotor. Rotor magnets to be time-stable, nontoxic ceramic magnets (Sr-Fe).
2. Driven by a frequency converter with an integrated power factor correction filter. Conventional induction motors will not be acceptable.
3. Each motor with an integrated variable-frequency drive, tested as one unit by manufacturer.
4. Motor speed adjustable over full range from 0 rpm to maximum scheduled speed.

5. Variable motor speed to be controlled by a 0- to 10 V-dc or 4- to 20-mA input.
6. Integrated motor protection verified by UL to protect the pump against over-/undervoltage, overtemperature of motor and/or electronics, overcurrent, locked rotor, and dry run (no-load condition).

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
- C. Examine foundations and inertia bases for suitable conditions where pumps will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION

- A. Comply with HI 1.4.
- B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
- C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- D. Equipment Mounting for In-Line Pumps Suspended from Structure: Install in-line pumps with continuous-thread hanger rods and elastomeric hangers of size required to support weight of in-line pumps.
 1. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.3 PIPING CONNECTIONS

- A. Where installing piping adjacent to pump, allow space for service and maintenance.
- B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- C. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- D. Install check valve and throttling valve with memory stop on discharge side of pumps.
- E. Install Y-type strainer and shutoff valve on suction side of pumps.
 - 1. Use startup strainer for initial system startup. Install permanent strainer element before turnover of system to Owner.
- F. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- G. Install pressure gauges on pump suction and discharge or at integral pressure-gauge tapping, or install single gauge with multiple-input selector valve.

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 shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."

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."

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping. Use startup strainer for initial startup.
 - 4. 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 correct direction.
 - 5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
 - 6. Start motor.
 - 7. Open discharge valve slowly.

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. Perform tests and inspections with the assistance of a factory-authorized service representative.
- D. Hydronic pumps will be considered defective if they do not pass tests and inspections.

- E. Prepare test and inspection reports.

3.8 DEMONSTRATION

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

END OF SECTION

SECTION 23 23 00

REFRIGERANT PIPING

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Copper tube and fittings.
2. Valves and specialties.
3. Refrigerants.

1.2 ACTION SUBMITTALS

A. Product Data Submittals: For each product.

1. Submit data for each type of refrigerant piping, fitting, valve, piping specialty, and refrigerant.

B. Delegated Design Submittals: For refrigerant piping size and 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.

C. Shop Drawings:

1. 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.
2. Show interface and spatial relationships between piping and equipment.

3. Shop Drawing Scale: 1/4 inch equals 1 foot (1:50).

1.3 INFORMATIONAL SUBMITTALS

- A. Welding Certificates: For each welder performing shop or field welding on Project.
- B. Field Quality-Control Reports: For each field quality control test and inspection.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel in accordance with ASME Boiler and Pressure Vessel Code: Section IX, "Welding, Brazing, and Fusing Qualifications."

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.
- B. Prepare valves and specialties for shipping as follows:
 1. Protect internal parts against rust and corrosion.
 2. Protect threads and other end connections.
- C. Use the following precautions during storage:
 1. Maintain valve and specialty end protection.
 2. Store valves and specialties indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," for refrigerant piping size and 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.
- B. Comply with ASHRAE 15-2022.
- C. Comply with ASME B31.5.
- D. Test Pressure for Refrigerant R-454B:
 - 1. Suction Tubing for Refrigeration and Air-Conditioning Applications Other than Heat Pumps: 300 psig (2068 kPa).
 - 2. Suction Tubing for Heat-Pump Applications: 600 psig (4137 kPa).
 - 3. Hot-Gas and Tubing Lines: 600 psig (4137 kPa).

2.2 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B88, Type K or L (ASTM B88M, Type A or B).
- B. Wrought-Copper Fittings, Solder Joint: ASME B16.22.
- C. Wrought-Copper Fittings, Brazed Joint: ASME B16.50.
- D. Wrought-Copper Unions: ASME B16.22.
- E. Solder Filler Metals: ASTM B32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
- F. Brazing Filler Metals: AWS A5.8M/A5.8.
- G. 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 (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
 4. Working Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
 5. Maximum Operating Temperature: 250 deg F (121 deg C).
- H. Copper-Tube, Pressure-Seal-Joint Fittings for Refrigerant Piping:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conex Banninger - USA.
 - b. Mueller Streamline Co.; a company of Mueller Industries.
 - c. Parker Hannifin; Sporlan Division.
 - d. RLS LLC.
 2. Standard: UL 207; certified by UL for field installation. Certification as a UL-recognized component alone is unacceptable.
 3. Housing: Copper.
 4. O-Rings: HNBR compatible with specific refrigerant.
 5. Tools: Manufacturer's approved special tools.
 6. Minimum Rated Pressure: 700 psig (48 bar).
 - a. VALVES AND SPECIALTIES
- I. Refrigerant Locking Caps:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. C & D Valve, LLC.
 - b. JB Industries.
 - c. RectorSeal HVAC; a CSW Industrials Company.
 - d. Refrigeration Sales, Inc.
 2. Description: Locking-type, tamper-resistant, threaded caps to protect refrigerant-charging ports from unauthorized refrigerant access and leakage.
 3. Material: Brass, with protective shroud or sleeve.
 4. Refrigerant Identification: Color-coded, refrigerant specific based on AHRI Guideline N or Universal design.
 5. Special Tool: For installing and unlocking.

2.3 REFRIGERANTS

- A. R-454B, ASHRAE 15-2022 and UL60335-2-40.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arkema Inc.
 - b. Honeywell International Inc.
 - c. Mexichem Fluor, Inc. (Koura).
 - d. The Chemours Company.
- B. R-32, ASHRAE 15-2022 and UL60335-2-40.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arkema Inc.
 - b. Honeywell International Inc.
 - c. Mexichem Fluor, Inc. (Koura).
 - d. The Chemours Company.

PART 3 - EXECUTION

3.1 PIPING APPLICATION SCHEDULES

- A. Refrigerant: R32 and R454B.
- B. Suction, Hot-Gas, and Liquid Tubing for Conventional Air-Conditioning (Cooling-Only) Applications, NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
- C. Suction, Hot-Gas, and Liquid Tubing for Heat-Pump Applications, NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
- D. Suction, Hot-Gas, and Liquid Tubing for Heat-Pump Applications, NPS 2 to NPS 4 (DN 50 to DN 100): Copper, Type ACR Type L (B), drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Provide refrigerant locking caps on refrigerant charging ports that are located outdoors unless otherwise protected from unauthorized access by a means acceptable to authority having jurisdiction.

3.3 INSTALLATION OF PIPING, GENERAL

- 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 in accordance with 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 rigid or flexible conduit in locations where exposed to mechanical injury.
- N. 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. Liquid lines may be installed level.

- O. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- P. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- Q. Identify refrigerant piping and valves in accordance with Section 230553 "Identification for HVAC Piping and Equipment."
- R. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230500 "Common Work Results for HVAC."
- S. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230500 "Common Work Results for HVAC."
- T. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230500 "Common Work Results for HVAC."

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 in accordance with AWS BRH, "Brazing Handbook," Ch. 35, "Pipe and Tubing."
 - 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.

3.5 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for seismic restraints in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Comply with Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.
- C. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 ft. (6 m) long.
 - 2. Roller hangers and spring hangers for individual horizontal runs 20 ft. (6 m) or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 ft. (6 m) 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.
- D. Install hangers for copper tubing, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- E. Support horizontal piping within 12 inches (300 mm) of each fitting.
- F. Support vertical runs of copper tubing to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. 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 must maintain test pressure at the manifold gauge 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.
- C. 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 (67 Pa). 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 (14 kPa).
 - 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, in accordance with 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 but not 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 23 25 00

HVAC WATER TREATMENT

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. HVAC water treatment.
2. Manual chemical-feed equipment.
3. Automatic chemical-feed equipment.
4. Chemicals.
5. Inhibited ethylene glycol and propylene glycol.
6. Filtration equipment.

1.2 DEFINITIONS

- A.** EEPROM: Electrically erasable, programmable read-only memory.
- B.** PPM: Parts per million.
- C.** RO: Reverse osmosis.
- D.** TDS: Total dissolved solids consist of salts and other materials that combine with water as a solution.
- E.** TSS: Total suspended solids include both organic and inorganic solids that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.3 ACTION SUBMITTALS

- A.** Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:

1. Chemical solution tanks.
 2. Injection pumps.
 3. Chemical test equipment.
 4. Chemical material safety data sheets.
 5. Inhibited ethylene glycol.
 6. Inhibited propylene glycol.
- B. Shop Drawings: Pretreatment equipment and chemical-treatment equipment, showing tanks, maintenance space required, and piping connections to HVAC systems.
1. Include plans, elevations, sections, and attachment details.
 2. Include diagrams for power and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For **chemical-treatment equipment** 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.
- B. Water-Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.
- C. Field quality-control reports.
- D. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.
- E. Water Analysis: Illustrate water quality available at Project site.
- F. Passivation Confirmation Report: Verify passivation of galvanized-steel surfaces, and confirm this observation in a letter to Architect.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider, capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

PART 2 - PRODUCTS

2.1 HVAC WATER TREATMENT

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Aqua-Chem, Inc.
 2. Barclay Water Management, Inc.
 3. Metro Group, Inc. (The).
 4. Nalco; an Ecolab company.
 5. NEPTUNE.

2.2 PERFORMANCE REQUIREMENTS

- A. Provide all hardware, chemicals, and other material necessary to maintain HVAC water quality in all systems as indicated in this Specification. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or to the environment.
- B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
- C. Closed hydronic systems, including **glycol heating** shall have the following water qualities:
1. pH: Maintain a value within 8.0 to 8.5
 2. Alkalinity: Maintain a value within 70 to 300 mg/L as CaCO₃.
 3. Steel Corrosion Inhibitors: Provide sufficient inhibitors to limit mild steel corrosion to ≤ 2 mils per year. Maintain soluble iron concentrations at or below <Insert value> mg/L.

4. Yellow Metal Corrosion Inhibitor: Provide sufficient copper and brass corrosion inhibitors to limit copper corrosion to ≤ 0.1 mils per year. Maintain soluble copper concentrations at or below 0.1 mg/L.
5. Scale Control: Provide softened water for initial fill and makeup. **Where softened water is not used, provide sufficient scale inhibitors to prevent formation of scale and maintain all scale-forming material in solution.**
6. Dispersants: Provide sufficient dispersants to prevent sedimentation of fine particulate matter.
7. Microbiological Limits:
 - a. Total Aerobic Plate Count: Maintain a maximum value of 10^3 organisms/mL.
 - b. Total Anaerobic Plate Count: Maintain a maximum value of 10^3 organisms/mL.
 - c. Nitrate Reducers: Maintain a maximum value of 10^2 organisms/mL.
 - d. Sulfate Reducers: Maintain a maximum value of 10^2 organisms/mL.
 - e. Iron Bacteria: Maintain a maximum value of 10^2 organisms/mL.
8. Other Requirements: Maintain glycol concentration and inhibitor levels per manufacturer's recommendations for freeze protection and corrosion control.

2.3 MANUAL CHEMICAL-FEED EQUIPMENT

- A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch (89-mm) fill opening in the top, and NPS 3/4 (DN 20) bottom inlet and top side outlet. Provide quarter- turn or threaded fill cap with gasket seal and diaphragm arranged to lock the top onto the feeder when exposed to system pressure in the vessel. Provide a NPS 3/4 IN (DN 20) quarter-turn valve on inlet and outlet.
 1. Capacity: **5 gal. (19 L)**
 2. Minimum Working Pressure: **125 psig (860 kPa)**

2.4 CHEMICALS

- A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

2.5 INHIBITED ETHYLENE GLYCOL AND PROPYLENE GLYCOL

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

1. CORECHEM.
2. Dynalene.
3. Fremont Industries.
4. Houghton Chemical Corp.
5. The Dow Chemical Company.

B. Inhibited Propylene Glycol:

1. Propylene glycol with inhibitor additive, to provide freeze protection for heat-transfer fluid and corrosion protection for carbon-steel, brass, copper, stainless steel, and cast-iron piping and fittings.
2. Inhibitor creates a passive layer on all surfaces that contact propylene glycol to prevent corrosion and stabilizes fluid pH, to compensate for acids formed from glycol degradation.
3. pH value shall be maintained between 8.0 and 8.5, with reserve alkalinity greater than 10 mL.
4. Operating Temperature Range: **Minus 50 deg F (minus 46 deg C) to 250 deg F (121 deg F)**
5. Concentrated inhibited propylene glycol is to be 95.5 percent propylene glycol by weight and 4.5 percent performance additives.
6. Concentrated inhibited propylene glycol is mixed with water in proper proportion specified by the manufacturer to provide freeze protection to **minus 20 deg F (minus 29 deg C)**. Premixed heat-transfer fluid may be used, or glycol/water mixture may be prepared at the time of installation. Use only deionized water for mixing.
7. Provide only propylene glycol that is specifically blended for HVAC application. Automotive-type antifreeze is unacceptable.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

- A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

- A. Install chemical-application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units, so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate. Install all chemical application equipment within a spill-containment area without floor drains.

- B. Install seismic restraints for equipment and floor-mounting accessories, and anchor to building structure. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- C. Install water-testing equipment on wall near water-chemical-application equipment.
- D. Install interconnecting control wiring for chemical-treatment controls and sensors.
- E. Mount sensors and injectors in piping circuits.
- F. Bypass Feeders: Install in closed hydronic systems, including **glycol heating** and equip with the following:
 - 1. Install bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.

FIELD QUALITY CONTROL

- G. Testing Agency:
 - 1. Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Engage a qualified testing agency to perform tests and inspections.
- H. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- I. Perform tests and inspections **with the assistance of a factory-authorized service representative.**
- J. Tests and Inspections:
 - 1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
 - 2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
 - 3. Place HVAC water-treatment system into operation, and calibrate controls during the preliminary phase of HVAC system's startup procedures.
 - 4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
 - 5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
 7. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
 8. Repair leaks and defects with new materials, and retest piping until no leaks exist.
- K. Equipment will be considered defective if it does not pass tests and inspections.
- L. Prepare test and inspection reports.

3.3 MAINTENANCE SERVICE

- A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above, to inhibit corrosion, scale formation, and biological growth for **heating, hot-water piping** and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:
1. Initial water analysis and HVAC water-treatment recommendations.
 2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
 3. Periodic field service and consultation.
 4. Customer report charts and log sheets.
 5. Laboratory technical analysis.
 6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

3.4 DEMONSTRATION

- A. **Engage a factory-authorized service representative to train** Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.
- B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment. When training is complete, turn over video to Owner for future use.

END OF SECTION

SECTION 23 29 23

VARIABLE-FREQUENCY MOTOR CONTROLLERS

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

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 separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.3 DEFINITIONS

- A. CE: Conformance Europeene (European Compliance).
- B. CPT: Control power transformer.
- C. DDC: Direct digital control.
- D. EMI: Electromagnetic interference.
- E. LED: Light-emitting diode.
- F. NC: Normally closed.
- G. NO: Normally open.

- H. OCPD: Overcurrent protective device.
- I. PID: Control action, proportional plus integral plus derivative.
- J. RFI: Radio-frequency interference.
- K. VFC: Variable-frequency motor controller. Also referred to as VFD or variable frequency drives and VSD or variable speed drives.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type and rating of VFC indicated.
 - 1. Include dimensions and finishes for VFCs.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For each VFC indicated.
 - 1. Include 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.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Required working clearances and required area above and around VFCs.
 - 2. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements.
 - 3. Show support locations, type of support, and weight on each support.
 - 4. Indicate field measurements.
- B. Qualification Data: For testing agency.
- C. Product Certificates: For each VFC from manufacturer.
- D. Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519.

- E. Source quality-control reports.
- F. Field quality-control reports.
- G. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Form 819 Article 1.20-1.05.02 and NOTICE TO CONTRACTOR - CLOSEOUT DOCUMENTS.
 - a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
 - b. Manufacturer's written instructions for setting field-adjustable overload relays.
 - c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
 - d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
 - e. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

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. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three 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. Indicating Lights: Two of each type and color installed.
 - 4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
 - 5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

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 DELIVERY, STORAGE, AND HANDLING

- A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating, with at least 250 W per controller.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

1.10 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 BUY AMERICA COMPLIANCE

- A. Products must meet Buy America requirements. Refer to NOTICE TO CONTRACTOR – BUY AMERICA for additional information.

2.2 SYSTEM DESCRIPTION

- A. General Requirements for VFCs:
 1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.
- B. Application: Variable torque.

- C. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
 - 1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
 - 2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
 - 3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
- D. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- E. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.
- F. Unit Operating Requirements:
 - 1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.
 - 2. Input AC Voltage Unbalance: Not exceeding 3 percent.
 - 3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
 - 4. Minimum Efficiency: 97 percent at 60 Hz, full load.
 - 5. Minimum Displacement Primary-Side Power Factor: 98 percent under any load or speed condition.
 - 6. Minimum Short-Circuit Current (Withstand) Rating: To match upstream panelboard or as indicated as required based on the short circuit study specified in Section 260573 "Overcurrent Protective Device Coordination Study And Arc Flash Hazard Analysis."
 - 7. Ambient Temperature Rating: Not less than 32 deg F and not exceeding 104 deg F.
 - 8. Humidity Rating: Less than 95 percent (noncondensing).
 - 9. Altitude Rating: Not exceeding 3300 feet.
 - 10. Vibration Withstand: Comply with NEMA ICS 61800-2.

11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
 12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
 13. Speed Regulation: Plus or minus 5 percent.
 14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
 15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
- G. Inverter Logic: Microprocessor based, 32 bit, isolated from all power circuits.
- H. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
1. Signal: Electrical.
- I. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
 2. Maximum Speed: 80 to 100 percent of maximum rpm.
 3. Acceleration: 0.1 to 999.9 seconds.
 4. Deceleration: 0.1 to 999.9 seconds.
 5. Current Limit: 30 to minimum of 150 percent of maximum rating.
- J. Self-Protection and Reliability Features:
1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2.
 2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
 3. Under- and overvoltage trips.
 4. Inverter overcurrent trips.
 5. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
 6. Critical frequency rejection, with three selectable, adjustable deadbands.
 7. Instantaneous line-to-line and line-to-ground overcurrent trips.
 8. Loss-of-phase protection.
 9. Reverse-phase protection.
 10. Short-circuit protection.
 11. Motor-overtemperature fault..

- K. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.
- L. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.
- M. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.
- N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- P. Integral Input Disconnecting Means and OCPD: UL 489, molded-case switch, with power fuse block and current-limiting fuses with pad-lockable, door-mounted handle mechanism.
 - 1. Disconnect Rating: Not less than 115 percent of VFC input current rating.
 - 2. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
 - 3. Auxiliary Contacts: NO or NC, arranged to activate before switch blades open.

2.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: VFCs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7. The designated VFCs shall be tested and certified by an NRTL as meeting the ICC-ES AC 156 test procedure requirements.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 CONTROLS AND INDICATION

- A. Status Lights: Door-mounted LED indicators displaying the following conditions:

VARIABLE FREQUENCY MOTOR CONTROLLERS

1. Power on.
 2. Run.
 3. Overvoltage.
 4. Line fault.
 5. Overcurrent.
 6. External fault.
- B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
 2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
 - a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.
- C. Historical Logging Information and Displays:
1. Real-time clock with current time and date.
 2. Running log of total power versus time.
 3. Total run time.
 4. Fault log, maintaining last four faults with time and date stamp for each.
- D. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including, but not limited to:
1. Output frequency (Hz).
 2. Motor speed (rpm).
 3. Motor status (running, stop, fault).
 4. Motor current (amperes).
 5. Motor torque (percent).
 6. Fault or alarming status (code).
 7. PID feedback signal (percent).
 8. DC-link voltage (V dc).
 9. Set point frequency (Hz).
 10. Motor output voltage (V ac).
- E. Control Signal Interfaces:
1. Electric Input Signal Interface:

- a. A minimum of two programmable analog inputs: 0- to 10-V dc or 4- to 20-mA dc.
 - b. A minimum of six multifunction programmable digital inputs.
 2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the DDC system for HVAC or other control systems:
 - a. 0- to 10-V dc.
 - b. 4- to 20-mA dc.
 - c. Potentiometer using up/down digital inputs.
 - d. Fixed frequencies using digital inputs.
 3. Output Signal Interface: A minimum of two programmable analog output signal(s) (0- to 10-V dc or 4- to 20-mA dc), which can be configured for any of the following:
 - a. Output frequency (Hz).
 - b. Output current (load).
 - c. DC-link voltage (V dc).
 - d. Motor torque (percent).
 - e. Motor speed (rpm).
 - f. Set point frequency (Hz).
 4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
 - a. Motor running.
 - b. Set point speed reached.
 - c. Fault and warning indication (overtemperature or overcurrent).
 - d. PID high- or low-speed limits reached.
- F. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.
 1. Number of Loops: Two.
- G. Interface with DDC System for HVAC: Factory-installed hardware and software shall interface with DDC system for HVAC to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory.
 1. Hardwired Points:
 - a. Monitoring: On-off status.
 - b. Control: On-off operation.
 2. Communication Interface: Comply with ASHRAE 135. Communication shall interface with DDC system for HVAC to remotely control and monitor lighting from a DDC system for HVAC operator workstation. Control features and

monitoring points displayed locally at lighting panel shall be available through the DDC system for HVAC.

- H. Interface with the Fire Alarm System: Interface with the fire alarm system to allow remote operation of all VFD's serving stair pressurization system by the fire alarm system.
 - 1. Hardwired Points:
 - a. Monitoring: On-off status.
 - b. Control: On-off operation for all fans with VFD's.
 - c. Request for run: On operation for all fans other than stair pressurization fans.
 - 2. Communication Interface: Communication shall interface with DDC system for the fire alarm system to remotely control and monitor lighting from a DDC system for HVAC operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the DDC system for HVAC. Provide BACnet MSTP integration protocol for integration with DDC.

2.5 LINE CONDITIONING AND FILTERING

- A. Input Line Conditioning: Based on the manufacturer's harmonic analysis study and report, provide input filtering, as required, to limit total demand (harmonic current) distortion and total harmonic voltage demand at the defined point of common coupling to meet IEEE 519 recommendations.
- B. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.

2.6 OPTIONAL FEATURES

- A. Multiple-Motor Capability: VFC suitable for variable-speed service to multiple motors. Overload protection shuts down VFC and motors served by it, and generates fault indications when overload protection activates.
 - 1. Configure to allow two or more motors to operate simultaneously at the same speed; separate overload relay for each controlled motor.
 - 2. Configure to allow two motors to operate separately; operator selectable via local or remote switch or contact closures; single overload relay for both motors; separate output magnetic contactors for each motor.
 - 3. Configure to allow two motors to operate simultaneously and in a lead/lag mode, with one motor operated at variable speed via the power converter and

the other at constant speed via the bypass controller; separate overload relay for each controlled motor.

- B. Automatic Damper control circuit with end-of-travel feedback capability. The automatic damper control circuit shall close a dry contact upon a manual or automatic start (run) command to open a control damper before the motor is allowed to operate in normal or bypass mode regardless of the source of the run command. When the damper is fully open (via damper position device-normally open dry contact) the motor will be allowed to operate. If any of the VFD safety interlock inputs are activated (freezestat, pressure safety, damper end switch, smoke alarm, etc.) the motor will stop (normal or bypass mode) and the automatic damper shall close. Provide time delay relay to allow the automatic damper to remain open until the motor stops.
- C. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an increase in speed-command signal deviation, VFC resumes normal operation.
- D. Motor Preheat Function: Preheats motor when idle to prevent moisture accumulation in the motor.
- E. Firefighter's Override (Smoke Purge) Input: On a remote contact closure from the firefighter's control station, this password-protected input:
 - 1. Overrides all other local and external inputs (analog/digital, serial communication, and all keypad commands).
 - 2. Forces VFC to operate motor, without any other run or speed command, at a field-adjustable, preset speed.
 - 3. Forces VFC to transfer to bypass mode and operate motor at full speed.
 - 4. Causes display of override mode on the VFC display.
 - 5. Reset VFC to normal operation on removal of override signal automatically.
- F. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.
- G. Remote digital operator kit.
- H. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.

2.7 ENCLOSURES

- A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.
 - 1. Dry and Clean Indoor Locations: Type 1.
 - 2. Outdoor Locations: Type 4X, stainless steel.
 - 3. Kitchen or Wash-Down Areas: Type 4X, stainless steel.
 - 4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.
- B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

2.8 ACCESSORIES

- A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.
 - 1. Push Buttons: [Covered].
 - 2. Pilot Lights: Push to test.
 - 3. Selector Switches: Rotary type.
- B. Reversible NC/NO bypass contactor auxiliary contact(s).
- C. Control Relays: Auxiliary and adjustable solid-state time-delay relays.
- D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
 - 1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.
- E. Supplemental Digital Meters:
 - 1. Elapsed-time meter.
 - 2. Kilowatt meter.
 - 3. Kilowatt-hour meter.
- F. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

- G. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- H. Cooling Fan and Exhaust System: For NEMA 250, Type 1; UL 508 component recognized: Supply fan, with composite intake and exhaust grills and filters; -V ac; obtained from integral CPT.
- I. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.
- J. Spare control-wiring terminal blocks; unwired.

2.9 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.
 - 1. Test each VFC while connected to a motor that is comparable to that for which the VFC is rated.
 - 2. Verification of Performance: Rate VFCs according to operation of functions and features specified.
- B. VFCs 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, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.
- B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

- 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 INSTALLATION

- A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."
- B. Floor-Mounting Controllers: Install VFCs on 4-inch nominal thickness concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
 - 2. For supported 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 embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- C. Roof-Mounting Controllers: Install VFC on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.
 - 1. Curbs and roof penetrations are specified in Section 077200 "Roof Accessories."
 - 2. Structural-steel channels are specified in Section 260529 "Hangers and Supports for Electrical Systems."
- D. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- E. Install fuses in each fusible-switch VFC.

- F. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."
- G. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors are installed.
- H. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
- I. Comply with NECA 1.

3.3 CONTROL WIRING INSTALLATION

- A. Install wiring between VFCs and remote devices and facility's central-control system. Comply with requirements in Section 260519 "Low Voltage Electrical Power Conductors and Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic-control devices where applicable.
 - 1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
 - 2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.4 IDENTIFICATION

- A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each VFC with engraved nameplate.
 - 3. Label each enclosure-mounted control and pilot device.
- B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
 - 2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
 - 3. Test continuity of each circuit.
 - 4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Architect and Owner before starting the motor(s).
 - 5. Test each motor for proper phase rotation.
 - 6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 8. Perform the following infrared (thermographic) 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 VFC. 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 VFC 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.
 - 9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D. VFCs will be considered defective if they do not pass tests and inspections.

- E. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

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.

3.7 ADJUSTING

- A. 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.
- B. Set the taps on reduced-voltage autotransformer controllers.
- C. Set field-adjustable circuit-breaker trip ranges. Mechanical contractor to coordinate this with the electrical contractor.
- D. Set field-adjustable pressure switches.

3.8 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.
- B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

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

END OF SECTION

SECTION 23 31 13

METAL DUCTS

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Single-wall round and flat-oval ducts and fittings.
3. Sheet metal materials.
4. Duct liner.
5. Sealants and gaskets.
6. Hangers and supports.
7. Sleeves and sealing through partitions.

B. Related Requirements:

1. Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraint devices and installation.
2. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
3. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.2 DEFINITIONS

- A. SMACNA: (The) Sheet Metal and Air Conditioning Contractors' National Association.**

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. Sustainable Design Submittals:

1. Product Data: For adhesives, indicating VOC content.
2. Product Data: For sealants, indicating VOC content.

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 and bottom of ducts.
5. Dimensions of all 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, seismic restraints, and vibration isolation.

D. Delegated Design Submittals:

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:
 - a. Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports.
 - b. Materials, fabrication, assembly and spacing of hangers and supports.
 - c. Reinforcement details and spacing.

1.4 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.
- B. Welding certificates.
- C. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
- B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
- C. Welding Qualifications: Qualify procedures and personnel in accordance with 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 supports.
 - 3. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for duct joint and seam welding.

PART 2 - PRODUCTS

2.1 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 and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7.
 - 1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
 - 2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
 - 3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.
- C. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
- D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Startup."
- E. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
- F. Duct Dimensions: Unless otherwise indicated, all duct dimensions indicated on Drawings are inside clear dimensions and do not include insulation or duct wall thickness.

2.2 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.
 - 1. Construct ducts of galvanized sheet steel unless otherwise indicated.
 - 2. For ducts exposed to weather, construct of Type 316 stainless steel indicated by manufacturer to be suitable for outdoor installation.
 - 3. The following fitting connections and duct construction gauges are not acceptable:
 - a. Drive slip [T-1, T-2] fitting connections.
 - b. 26 Gauge ductwork.

- B. Transverse Joints: T-24 flanged with corner pieces 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: Pittsburgh lock with 3/8-inch minimum pocket 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 as shown in the drawing details: 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."
- E. Ductwork not insulated and larger than 18" shall be either cross broken or beaded.
- F. Long radius bends (centerline radius $1.5 \times$ duct major dimension) shall be used unless indicated otherwise on the drawings. Short radius bend may be used where indicated or where approved by the engineer, and shall include proportional radius full vanes or nested elbows per SMACNA.
 - 1. Mitered elbows with turning vanes shall not be used, shall be welded to runners and shall have an installed "C" coefficient not greater than 0.12. even where indicated on the drawings, unless approved in writing by Engineer. and Northeastern University. Mitered elbows without turning vanes are not acceptable except in lined transfer duct applications.
- G. Where mitered bends with turning vanes are approved vanes shall be factory installed to ensure correct alignment within the duct.
- H. Unless otherwise shown on the contract drawings, all elbows shall have a throat radius equal to the width of the duct in the direction of the elbow.
- I. All branch ducts shall be provided with take-off pieces including 45-degree angled sides as per SMACNA Figure 2-6. Straight taps shall not be acceptable.

2.3 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ductmate Industries, Inc.
 - b. Linx Industries (formerly Lindab).
 - c. McGill AirFlow LLC.
 - d. MKT Metal Manufacturing.
 - e. SEMCO, LLC; part of FlaktGroup.
 - f. Sheet Metal Connectors, Inc.
 - g. Spiral Manufacturing Co., Inc.
 2. Construct ducts of galvanized sheet steel unless otherwise indicated.
 3. For ducts exposed to weather, construct of Type 316 stainless steel indicated by manufacturer to be suitable for outdoor installation.
 4. The following seam and duct construction gauges are not acceptable:
 - a. Snap-lock longitudinal seams.
 - b. 26 Gauge ductwork.
- B. Source Limitations: Obtain single-wall round and flat oval 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).
- D. 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."
1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
- E. 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."

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.
- F. 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."

2.4 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 A653/A653M.
1. Galvanized Coating Designation: G90.
 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
 3. 24-Gauge (0.027", 0.66mm) minimum thickness notwithstanding duct pressure class.
- C. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304 or 316, as indicated in "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in "Duct Schedule" Article. Thickness shall be not less than 18 gauge (0.050", 1.25 mm) for welding
- D. 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.
- E. All ductwork shall have the metal gauge visibly marked on all sections by manufacturer.

2.5 DUCT LINER

- A. Duct liner shall not be acceptable except and unless where used in a double-wall duct application, with no fibers exposed to the airstream.

2.6 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 in accordance with 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. Sealant shall have a VOC content of 420 g/L or less.
- 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 C920.

1. General: Single-component, acid-curing, silicone, elastomeric.
 2. Type: S.
 3. Grade: NS.
 4. Class: 25.
 5. Use: O.
 6. Sealant shall have a VOC content of 420 g/L or less.
- E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- F. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg 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.

2.7 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Galvanized-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 A603.
- E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A492.
- F. Steel Cable End Connections: Galvanized-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 in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install ducts in maximum practical lengths with fewest possible joints.
- D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- G. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.
- H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

- I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).
- J. Install fire, combination fire/smoke, and smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.
- K. Install heating coils, cooling coils, air filters, dampers, and all other duct-mounted accessories in air ducts where indicated on Drawings.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."
- M. Elbows: Use long-radius elbows wherever they fit. (centerline radius 1.5 x the major duct dimension), as the default elbow configuration.
 - 1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
 - 2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.
 - 3. Where long-radius elbows cannot fit in a coordinated condition, the following general hierarchy shall be used:
 - a. Gradually shorter radius elbows with full-sweep, radius-proportional vanes or nested elbows per SMACNA. Such shorter radii shall reduce incrementally to fit but shall be no smaller than a throat radius of 0.50 x the major duct dimension. (Square-throat/radius heel elbows will not be acceptable.
 - b. Mitered elbows with welded turning vanes and a C coefficient of not more than 0.12.
- N. Branch Connections: Use tapered lateral or conical branch connections.
- O. Duct liner:
 - 1. Duct liner will not be acceptable on this project except and unless it is within a double-wall duct system with no fibers exposed to the airstream.

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 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.
- F. Primed paint materials and application requirements are specified in Section 099113 "Exterior Painting."

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR TYPE 1 COMMERCIAL KITCHEN GREASE HOOD EXHAUST DUCT

- A. Install ducts in accordance with NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operation"; SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; and SMACNA's "Kitchen Ventilation Systems and Food Service Equipment Fabrication and Installation Guidelines" unless otherwise indicated.
- B. Install all ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.
- C. All ducts exposed to view are to be constructed of stainless steel as per "Duct Schedule" Article. All ducts concealed from view are to be stainless steel as per "Duct Schedule" Article.

- D. All joints are to be welded and are to be telescoping, bell, or flange joint as per NFPA 96.
- E. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 20 (6) feet (m) in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings.
- F. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.4 DUCTWORK EXPOSED TO WEATHER

- A. All external joints are to have secure watertight mechanical connections. Seal all openings to provide weatherproof construction.
- B. Construct ductwork to resist external loads of wind, snow, ice, and other effects of weather. Provide necessary supporting structures.
- C. Single Wall:
 - 1. Ductwork is to be Type 316 stainless steel.
 - 2. Ductwork is to be galvanized steel.
 - a. If duct outer surface is uninsulated, protect outer surface with suitable paint. Primed paint materials and application requirements are specified in Section 099113 "Exterior Painting."
 - 3. Where ducts have external insulation, provide weatherproof aluminum jacket. See Section 230713 "Duct Insulation."

3.5 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Seal ducts at a minimum to the following seal classes in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- 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 or for slabs more than 4 inches (100 mm) thick.
 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
 5. Do not use powder-actuated concrete fasteners for seismic restraints. Coordinate with Section 230548 "Vibration and Seismic Controls for HVAC."
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "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 (610 mm) of each elbow and within 48 inches (1220 mm) of each branch intersection.

- D. Hangers Exposed to View: Threaded rod and angle or channel supports or gripple hangers.
- E. 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 (5 m).
- F. 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 SEISMIC-RESTRAINT-DEVICE INSTALLATION

- A. See Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraint installation requirements.

3.8 DUCTWORK 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.

3.9 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."

3.10 FIELD QUALITY CONTROL

- A. All ductwork shall be "built clean" including fabrication, transportation, to installation. All ducts no matter what service shall after fabrication, have all openings sealed and these openings shall remain sealed until all connections are completed in the field.
 - 1. Ductwork construction shall conform to SMACNA "Duct Cleanliness for New Construction Guidelines" as a requirement, to "Advanced Level".
- B. Perform tests and inspections.
- C. Leakage Tests:
 - 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 - 2. Test the following systems:
 - a. All ducts: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - b. Above 25 percent shall include 100 percent of all ductwork to be concealed in shafts.
 - 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 - 4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
 - 5. Test for leaks before applying external insulation.
 - 6. Unless otherwise noted, conduct tests at static pressures equal to maximum design pressure 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.
 - 7. Give seven days' advance notice for testing.
 - 8. Locations of the test sections listed above are at the discretion of the Owner.
 - 9. Procedure:
 - a. Seal openings in ducts and plenums to be tested.
 - b. Connect test apparatus to test section using flexible duct connection or hose.
 - c. Close damper on blower suction side, to prevent excessive buildup of pressure.
 - d. Start blower and gradually open damper on suction side of blower.
 - e. Build up pressure in test section. Test supply air, return, exhaust and outside air to 100 percent of duct construction pressure rating.

- f. Determine amount of air leakage by makeup air flow measurements.
- g. Total allowable leakage is to be calculated using the formula $F = CL \times p \times 0.65$
- h. Where F = Allowable leakage per 100 square feet
- i. CL = Leakage classification
- j. P = Duct pressure classification
- k. Repair air leaks as required and retest when seals have cured until leakage rate is acceptable. Noise generated from duct leakage is not acceptable.
- l. Remove temporary blanks and seals as appropriate.
- m. Visually mark tested sections with certification sticker and initials of field test inspector.
- n. Submit certification of test results.

D. 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 in accordance with "Description of Method 3 - NADCA 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.
 - b. All temporary filters shall have a minimum efficiency of MERV-8.

E. Duct system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.11 DUCT CLEANING

- A. Clean new duct system(s) before testing, adjusting, and balancing. Facilities must approve before formal acceptance.
- B. Use duct cleaning methodology as indicated in NADCA ACR.
- C. Use service openings for entry and inspection.

1. Provide openings with access panels appropriate for duct static-pressure and leakage class at dampers, coils, and any other locations where required for inspection and 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.

D. 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.

E. 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.

F. 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 in accordance with NADCA ACR. 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 in accordance with manufacturer's written instructions after removal of surface deposits and debris.

3.12 STARTUP

- A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.13 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel with the following max minimum thickness gauge unless otherwise stated:
 1. High-pressure ductwork (Ductwork greater than 3.0 inches w.g. construction per SMACNA) must not be less than 24-gauge or as required per latest SMACNA Standard if lower.
 2. Low-pressure ductwork (Ductwork 3.0 inches w.g. construction and lower) must not be less than 24-gauge or greater thickness as required per latest SMACNA Standard. if lower.
 3. Nothing shall prohibit using 24-gauge sheet metal as the default minimum thickness, with reinforcement appropriate to meet the pressure category.
- B. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
 1. Laboratory exhaust ductwork
 - a. Fume Exhaust ducts, including current fume hoods, snorkel exhaust, biosafety cabinets (BSC's), fume hood ducts to be installed now but serving fume hoods slated for future: welded 316L stainless steel with 2B finish.
 - b. Ductwork associated with FEV (Fume Exhaust Valves), all scheduled in stainless steel, define this duct category.
 - c. Lab general exhaust, drawing from the space: Ducts shall be galvanized sheet metal.

- d. Ductwork associated with LEV (Lab Exhaust Valves), all scheduled in aluminum, define this duct category. Use gasket connections to isolate dissimilar metals.
 - e. Horizontal header: flanged, galvanized where fully accessible; welded stainless steel where not accessible.
 - f. Horizontal duct from header to terminal device or equipment: welded 316L stainless steel with 2B finish.
 - g. All stainless-steel ductwork shall be welded, with flanged or bell-fit compression fittings and gaskets at connections to equipment only.
2. Kiln exhaust ductwork: Welded 304 stainless steel.
 3. Kitchen exhaust ductwork: refer to Section 233533 "Listed Kitchen Ventilation System Exhaust Ducts."
 4. Lined ductwork: As indicated on drawings, including (but not limited to) supply ductwork in exposed ceilings.
 - a. Transfer Ducts and FCU supply and return: Fibrous-Glass Duct liner
 - b. Lined pressurize ductwork: Flexible Elastomeric Duct Liner
 5. Exposed ductwork in public occupied areas: round or oval.
 6. Subduct shall be constructed of 24GA. Galvanized steel. The bottom of the riser shall be capped and welded soldered water-tight.
 7. Ductwork downstream of AHUs with humidifiers or other vapor laden systems: welded stainless steel for first 20ft downstream of the humidifier or up and including the first elbow, whichever is first.
 8. Ducts Serving Showers
 - a. First ten (10) feet exhaust duct from grille located in shower room will be Aluminum.
 - b. Slope duct at ¼" per foot towards grille.
 9. Provide ductwork of pressure and seal class described in table below.

System	Pressure Classification	Seal Class	Rectangular Leakage Class	Round Leakage Class
Ductwork between outdoor in-take/discharge and terminal unit	6"	A	3	3
Ductwork between terminal unit and space	2"	A	3	3

C. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.
2. Stainless-Steel Ducts:
 - a. Exposed to Airstream: Match duct material.

3. Aluminum Ducts: Aluminum.

D. Liner:

1. Supply-Air Ducts: Fibrous glass, Type I, 1 inches thick.
2. Transfer Ducts: Fibrous glass, Type I, 1 inches thick.

E. 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 1.5 centerline radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 throat radius-to-diameter ratio and two vanes.
 - b. Velocity 1000 to 1500 fpm:
 - 1) Radius Type RE 1 with minimum 1.5 centerline radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 throat radius-to-diameter ratio and two vanes.
 - c. Velocity 1500 fpm or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 centerline radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 1.0 throat radius-to-diameter ratio and two vanes.
2. 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 throat radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm: 1.0 throat radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm or Higher: 1.5 centerline radius-to-diameter ratio and five segments for 90-degree elbow.
 - 4) Radius-to Diameter Ratio: 1.5.
 - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Welded.

- d. Adjustable elbows, including crimped elbows will not be acceptable.

F. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
2. Branches serving individual terminals and/or branch flow not exceeding 25% of main flow:
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Conical spin in or bellmouth.
3. Branches serving greater than 25% of main flow:
 - a. Rectangular Main to Rectangular Branch: Proportional split with radius elbow for branch.
 - b. Round Main to Round Branch: 45-degree Wye fitting and 45 degree elbow.
4. 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 400 fpm or Lower: 90-degree tap.(Single device service only.)
 - b. Velocity 400 to 1500 fpm: Conical tap.
 - c. Velocity 1500 fpm or Higher: 45-degree lateral.

3.14 SLEEVES FOR DUCTWORK

A. General Requirements

1. Furnish and install sheet metal sleeves per this paragraph. The objective is to maintain the integrity of penetrated partitions and their ratings against fire, smoke and airflow/pressurization requirements.
2. Sleeves shall be sealed with firestopping conforming to Section 078413 "Penetration Firestopping" unless the penetration is protected by a listed fire damper or fire-smoke damper, in which case those installation UL details shall apply.

- B. Interior drywall partitions and roof penetrations, unrated or with fire rating of 1-Hour or less: Galvanized-Steel Sheet Metal Sleeves per Paragraph 2.8 for the full circumference of duct. Sleeves shall be sealed with firestopping conforming to Section 078413 "Penetration Firestopping". Apply to full perimeter of penetration. Where exposed to view, provide safin plates all-around, both sides, after inspection.

- C. Interior masonry partitions or roof penetrations, unrated or with a fire rating of 1-Hour or less: Type 304 Stainless-Steel Sheet Metal Sleeves per Paragraph 2.8 for the full circumference of duct. Sleeves shall be sealed with firestopping conforming to Section 078413 "Penetration Firestopping". Apply to full perimeter of penetration. Where exposed to view, provide safining plates all-around, both sides, after inspection.
- D. Interior fire rated partitions with a rating greater than 1-Hour: UL-555 fire dampers and/or UL-555S fire and smoke dampers as appropriate for partition rating and service, within UL-conforming details, including sleeves and extended sleeves as part of the dampers.

END OF SECTION 233113

SECTION 23 33 00

AIR DUCT ACCESSORIES

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

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. Manual volume dampers.
3. Control dampers.
4. Fire dampers.
5. Smoke dampers.
6. Combination fire and smoke dampers.
7. Flange connectors.
8. Duct silencers.
9. Turning vanes.
10. Remote damper operators.
11. Duct-mounted access doors.
12. Duct access panel assemblies.
13. Flexible connectors.
14. Duct accessory hardware.

B. Related Requirements:

1. Section 233346 "Flexible Ducts" for insulated and non-insulated flexible ducts.

1.3 ACTION SUBMITTALS

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

1. For duct silencers, include pressure drop, dynamic insertion loss, and self-generated noise data. Include breakout noise calculations for high-transmission-loss casings.
- B. 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. Duct security bars.
 - f. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, or BIM model, 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 A653/A653M.
 - 1. Galvanized Coating Designation: G60 (Z180).
 - 2. Exposed-Surface Finish: Mill phosphatized.
- B. Stainless-Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2 finish for concealed ducts and No. 3 finish for exposed ducts.
- C. Aluminum Sheets: Comply with ASTM B209 (ASTM B209M), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- D. Extruded Aluminum: Comply with ASTM B221 (ASTM B221M), Alloy 6063, Temper T6.
- E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

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

1. Greenheck Fan Corporation.
 2. Nailor Industries Inc.
 3. Pottorff.
 4. Ruskin Company.
- B. Description: Gravity balanced.
- C. Performance:
1. Maximum Air Velocity: 2000 fpm (10 m/s).
 2. Maximum System Pressure: 6-inch wg (1.5 kPa).
 3. AMCA Certification: Test and rate in accordance with AMCA 511.
 4. Leakage:
 - a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
 - b. Class I: Leakage shall not exceed 4 cfm/sq. ft. (20 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
 - c. Class II: Leakage shall not exceed 10 cfm/sq. ft. (51 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
 - d. Class III: Leakage shall not exceed 40 cfm/sq. ft. (203 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
- D. Construction:
1. Frame: Hat-shaped, 0.063-inch- (1.6-mm-) thick extruded aluminum, with welded corners or mechanically attached and mounting flange.
 2. Blades: Multiple single-piece blades, end pivoted, maximum 6-inch (150-mm) width, 0.025-inch- (0.6-mm-) thick, roll-formed aluminum with sealed edges.
 3. Blade Action: Parallel.
 4. Blade Seals: Extruded vinyl, mechanically locked.
 5. Blade Axles:
 - a. Material: Aluminum.
 - b. Diameter: 0.20 inch (5 mm).
- E. Tie Bars and Brackets: Aluminum.
- F. Return Spring: Adjustable tension.
- G. Bearings: Steel ball or synthetic pivot bushings.
- H. Damper Actuator - Electric:
1. Electric - 24 V ac.
 2. UL 873 plenum rated.
 3. Two position with fail-safe spring return.
 - a. Sufficient motor torque and spring torque to drive damper fully closed with adequate force to achieve required damper seal.
 - b. Minimum 90-degree drive rotation.

4. Clockwise or counterclockwise drive rotation as required for application.
5. Environmental Operating Range:
 - a. Temperature: Minus 40 to plus 130 deg F (Minus 40 to plus 55 deg C).
 - b. Humidity: 5 to 95 percent relative humidity noncondensing.
6. Environmental Enclosure: NEMA 2.
7. Actuator to be factory mounted and provided with a single-point wiring connection.

I. Controllers, Electrical Devices, and Wiring:

1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

J. 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 gauge (1.0 mm) minimum.
 - b. Sleeve Length: 6 inches (152 mm) 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. Air Balance; a division of MESTEK, Inc.
 - b. Greenheck Fan Corporation.
 - c. McGill AirFlow LLC.
 - d. Nailor Industries Inc.
 - e. Pottorff.
 - f. Ruskin Company.
2. Performance:
 - a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. (203 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
3. Construction:
 - a. Linkage out of airstream.

- b. Suitable for horizontal or vertical airflow applications.
 - 4. Frames:
 - a. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) 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. Stainless-steel, 0.064 inch (1.62 mm) thick.
 - 6. Blade Axles: Stainless steel Nonferrous metal.
 - 7. Bearings:
 - a. Oil-impregnated stainless-steel sleeve.
 - b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) 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.
 - 9. Locking device to hold damper blades in a fixed position without vibration.
- B. Standard, Aluminum, Manual Volume Dampers:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. McGill AirFlow LLC.
 - b. Nailor Industries Inc.
 - c. Pottorff.
 - d. Ruskin Company.
 - 2. Performance:
 - a. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. (203 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
 - 3. Construction:
 - a. Linkage out of airstream.
 - b. Suitable for horizontal or vertical airflow applications.
 - 4. Frames:
 - a. Hat-shaped, 0.10-inch- (2.5-mm-) thick, aluminum sheet channels.
 - b. 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- (2.5-mm-) thick aluminum sheet.
 - e. Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum.
 - 6. Blade Axles: Galvanized steel.
 - 7. Bearings:
 - a. Oil-impregnated bronze.
 - b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 - 8. Tie Bars and Brackets: Aluminum.
 - 9. Locking device to hold damper blades in a fixed position without vibration.
- C. Low-Leakage, Steel, Manual Volume Dampers:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Greenheck Fan Corporation.
 - b. McGill AirFlow LLC.
 - c. Nailor Industries Inc.
 - d. Pottorff.
 - e. Ruskin Company.
 - 2. Comply with AMCA 500-D testing for damper rating.
 - 3. Performance:
 - a. AMCA Certification: Test and rate in accordance with AMCA 511.
 - b. Leakage:
 - 1) Class IA: Leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
 - 2) Class I: Leakage shall not exceed 4 cfm/sq. ft. (20 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
 - 3) Class II: Leakage shall not exceed 10 cfm/sq. ft. (51 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
 - 4. Construction:
 - a. Linkage: Out of airstream.
 - b. Suitable for horizontal or vertical airflow applications.
 - 5. Frames:
 - a. Hat shaped.
 - b. 0.094-inch- (2.4-mm-) thick, galvanized sheet steel.
 - c. Mitered and welded corners.
 - d. Flanges for attaching to walls and flangeless frames for installing in ducts.
 - 6. Blades:

- a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized, roll-formed steel, 0.064 inch (1.62 mm) thick.
- 7. Blade Axles: Galvanized steel.
 - 8. Bearings:
 - a. Oil-impregnated bronze.
 - b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 - 9. Blade Seals: Vinyl.
 - 10. Jamb Seals: Cambered stainless steel.
 - 11. Tie Bars and Brackets: Galvanized steel.
 - 12. Accessories:
 - a. Include locking device to hold single-blade dampers in a fixed position without vibration.

2.5 CONTROL DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck Fan Corporation.
 - 2. Pottorff.
 - 3. Ruskin Company.
- B. 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 or field assemble multiple damper sections to provide a single damper assembly of size required by the application.
- C. Performance:
 - 1. AMCA Certification: Test and rate in accordance with AMCA 511.
 - 2. Leakage:
 - a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
 - b. Class I: Leakage shall not exceed 4 cfm/sq. ft. (20 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
 - c. Class II: Leakage shall not exceed 10 cfm/sq. ft. (51 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
 - d. Class III: Leakage shall not exceed 40 cfm/sq. ft. (203 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.

3. Pressure Drop: 0.05 inch wg (12.5 Pa) at 1500 fpm (7.6 m/s) across a 24-by-24-inch (600-by-600-mm) damper when tested in accordance with AMCA 500-D, Figure 5.3.
4. Velocity: Up to 3000 fpm.
5. Temperature: Minus 25 to plus 180 deg F (Minus 32 to plus 83 deg C).
6. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

D. Construction:

1. Linkage out of airstream.
2. Suitable for horizontal or vertical airflow applications.
3. Frames:
 - a. Hat, U, or angle shaped.
 - b. 16-gauge- thick, galvanized sheet steel.
 - c. Mitered and welded corners.
 - d. Flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:
 - a. Multiple blade with maximum blade width of 6 inches.
 - b. Opposed-blade design.
 - c. Galvanized steel Aluminum.
 - d. 14-gauge- (1.9-mm-) thick air foil dual skin.
5. Blade Edging Seals:
 - a. Replaceable Closed-cell neoprene
 - b. Inflatable seal blade edging, or replaceable rubber seals.
6. Blade Jamb Seal: Flexible stainless steel, compression type.
7. Blade Axles: 1/2-inch (13-mm) diameter; galvanized steel.
8. Blade-Linkage Hardware: Zinc-plated steel and brass; ends sealed against blade bearings. Linkage mounted out of air stream.
9. Bearings:
 - a. Oil-impregnated bronze
 - b. Dampers mounted with vertical blades to have thrust bearings at each end of every blade.

E. Damper Actuator - Electric:

1. Electric - Comply with requirements for electrical devices and connections specified in Section 230900 "Building Management System"
2. UL 873, plenum rated.

F. Controllers, Electrical Devices, and Wiring:

1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

2.6 FIRE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck Fan Corporation.
 - 2. Pottorff.
 - 3. Ruskin Company.
- B. Type: Static and 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 and 3 hours.
- E. Frame: Curtain type with blades outside airstream (Type A) except when located behind grille where blades may be inside airstream (Type B); fabricated with roll-formed galvanized steel; with mitered and interlocking corners; gauge in accordance with UL listing.
- F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel; gauge in accordance with UL listing.
- G. Mounting Orientation: Vertical or horizontal as indicated.
- H. Blades: Roll-formed, interlocking, galvanized sheet steel; gauge in accordance with UL listing.
- 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. Greenheck Fan Corporation.
 - 2. Pottorff.
 - 3. Ruskin Company.
- B. General Requirements:
 - 1. Label to indicate conformance to UL 555 and UL 555S by an NRTL.
 - 2. Label to indicate conformance to NFPA 80 and NFPA 90A by an NRTL.

3. Unless otherwise indicated, use parallel-blade configuration.
4. Factory or field assemble multiple damper sections to provide a single damper assembly of size required by the application.
5. Factory install damper actuator by damper manufacturer as integral part of damper assembly. Coordinate actuator location, mounting, and electrical requirements with damper manufacturer.

C. Performance:

1. AMCA Certification: Test and rate in accordance with AMCA Publication 511.
2. Leakage:
 - a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
 - b. Class I: Leakage shall not exceed 4 cfm/sq. ft. (20 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
 - c. Class II: Leakage shall not exceed 10 cfm/sq. ft. (51 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
3. Pressure Drop: 0.05 inch wg (12.5 Pa) at 1500 fpm (7.6 m/s) across a 24-by-24-inch (600-by-600-mm) damper when tested in accordance with AMCA 500-D, Figure 5.3.
4. Velocity: Up to 3000 fpm.
5. Temperature: Minus 25 to plus 180 deg F (Minus 32 to plus 83 deg C).
6. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

D. Smoke Detector: To be provided by Division 28 and installed by Division 23.

E. Frame: Hat-shaped, galvanized sheet steel, with welded corners and mounting flange; gauge in accordance with UL listing.

F. Blades: Roll-formed, horizontal, interlocking galvanized sheet steel; gauge in accordance with UL listing.

G. Rated pressure and velocity to exceed design airflow conditions.

H. Mounting Sleeve: Factory-installed, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone caulking; gauge in accordance with UL listing.

I. Damper Actuator - Electric:

1. Electric - 120 V dc
2. UL 873, plenum rated.
3. Designed to operate in smoke-control systems complying with UL 555S requirements.
4. Two-position (open/close) with fail-safe spring return.

- a. Sufficient motor torque and spring torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
 - b. Maximum 15-second full-stroke closure.
 - c. Minimum 90-degree drive rotation.
 - 5. Clockwise or counterclockwise drive rotation as required for application.
 - 6. Environmental Operating Range:
 - a. Temperature: Minus 40 to plus 130 deg F ((Minus 40 to plus 55 deg C)).
 - b. Humidity: 5 to 95 percent relative humidity noncondensing.
 - 7. Environmental Enclosure: NEMA 2.
 - 8. Actuator to be factory mounted and provided with single-point wiring connection.
- J. Controllers, Electrical Devices, and Wiring:
- 1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
- K. Accessories:
- 1. Auxiliary switches for signaling.
 - 2. Momentary test switch, damper mounted.

2.8 COMBINATION FIRE AND SMOKE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 1. Greenheck Fan Corporation.
 - 2. Pottorff.
 - 3. Ruskin Company.
- B. General Requirements:
- 1. Label to indicate conformance to UL 555 and UL 555S by an NRTL.
 - 2. Label to indicate conformance to NFPA 80 and NFPA 90A by an NRTL.
 - 3. Unless otherwise indicated, use parallel-blade configuration.
- 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. Performance:
- 1. AMCA Certification: Test and rate in accordance with AMCE Publication 511.
 - 2. Leakage:

- a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. (15.2 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
 - b. Class I: Leakage shall not exceed 4 cfm/sq. ft. (20 L/s/ per sq. m) against 1-inch wg (250-Pa) differential static pressure.
 - c. Class II: Leakage shall not exceed 10 cfm/sq. ft. (51 L/s per sq. m) against 1-inch wg (250-Pa) differential static pressure.
3. Pressure Drop: 0.05 in. wg (12.5 Pa) at 1500 fpm (7.6 m/s) across a 24-by-24-inch (600-by-600-mm) damper when tested in accordance with AMCA 500-D, Figure 5.3.
4. Velocity: Up to 3000 fpm (15 m/s).
5. Temperature: Minus 25 to plus 180 deg F (Minus 32 to plus 83 deg C).
6. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
- F. Frame: Hat-shaped, galvanized sheet steel, with welded corners and mounting flange; gauge in accordance with UL listing.
- G. Heat-Responsive Device: Electric resettable device and switch package, factory installed, rated.
- H. Smoke Detector: To be provided by Division 28 and installed by Division 23. Vertical blades are available for special applications.
- I. Blades: Roll-formed, horizontal, interlocking, galvanized sheet steel; gauge in accordance with UL listing.
- J. Rated pressure and velocity to exceed design airflow conditions.
- K. Mounting Sleeve: Factory-installed, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone caulking; gauge in accordance with UL listing.
- L. Master control panel for use in dynamic smoke-management systems
- M. Damper Actuator - Electric:
 1. Electric – 24 V dc.
 2. UL 873, plenum rated.
 3. Designed to operate in smoke-control systems complying with UL 555S requirements.
 4. Two position (open/close) with fail-safe spring return.
 - a. Sufficient motor torque and spring torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
 - b. Maximum 15-second full-stroke closure.
 - c. Minimum 90-degree drive rotation.
 5. Clockwise or counterclockwise drive rotation as required for application.

6. Environmental Operating Range:
 - a. Temperature: Minus 40 to plus 130 deg F ((Minus 40 to plus 55 deg C)).
 - b. Humidity: 5 to 95 percent relative humidity noncondensing.
7. Environmental Enclosure: NEMA 2.
8. Actuator to be factory mounted and provided with single-point wiring connection.

N. Controllers, Electrical Devices, and Wiring:

1. Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

O. Accessories:

1. Auxiliary switches for signaling.
2. Momentary test switch, 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. Elgen Manufacturing.
- B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. Material: Galvanized steel.
- D. Gauge and Shape: Match connecting ductwork.

2.10 DUCT SILENCERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. FläktGroup.
 2. IAC Acoustics; a division of Sound Seal.
 3. McGill AirFlow LLC.
 4. Pottorff.
 5. Price Industries.
 6. Ruskin Company.
 7. 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 E84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
4. Bearing AMCA's Certified Ratings Seal for prefabricated silencer sound and air performance.

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 A653/A653M, G90, galvanized sheet steel, 0.034 inch thick.

E. Round Silencer Outer Casing: ASTM A653/A653M, G90, galvanized sheet steel.

1. Sheet Metal Thickness for Units up to 24 Inches (600 mm) in Diameter: 0.034 inch (0.85 mm) thick.
2. Sheet Metal Thickness for Units 26 through 40 Inches (660 through 1000 mm) in Diameter: 0.040 inch (1.02 mm) thick.
3. Sheet Metal Thickness for Units 42 through 52 Inches (1060 through 1300 mm) in Diameter: 0.05 inch (1.3 mm) thick.
4. Sheet Metal Thickness for Units 54 through 60 Inches (1370 through 1500 mm) in Diameter: 0.064 inch (1.62 mm) thick.

F. Inner Casing and Baffles: ASTM A653/A653M, G90 (Z275) galvanized sheet metal, 0.034 inch (0.85 mm) thick, and with 1/8-inch- (3-mm-) diameter perforations.

G. Special Construction:

1. Suitable for outdoor use.
2. High transmission loss to achieve STC 45.

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.
 3. Lining: Fiberglass cloth
 - 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: Lock formed and sealed or continuously welded.
 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 E477.
 1. Testing to be witnessed by Architect and Owner.
 2. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm (10-m/s) face velocity.
 3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg (1500-Pa) static pressure, whichever is greater.
- 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.
 - 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 48 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. METALAIRE, Inc.
 - 2. United Enertech.
 - 3. Young Regulator Company.
 - 4. Metropolitan.
- B. Description: Cable system designed for remote manual damper adjustment.
- C. Tubing: Brass, Copper, or Aluminum
- D. Cable: Stainless steel
- E. Wall-Box Mounting: Recessed.
- F. Wall-Box Cover-Plate Material: Stainless steel.

2.13 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ductmate Industries, Inc.
 - 2. Duro Dyne Inc.
 - 3. Elgen Manufacturing.
 - 4. McGill AirFlow LLC.
 - 5. Ruskin Company.
- B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "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 (25-by-25-mm) 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 (300 mm) Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches (460 mm) Square: Two hinges and two sash locks.
 - c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Three hinges and two compression latches with outside and inside handles.
 - d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Four hinges and two compression latches with outside and inside handles.

C. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.
2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Factory set at 3.0- to 8.0-inch wg
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 1-inch- (25-mm-) thick, fibrous-glass or polystyrene-foam board.

2.14 DUCT ACCESS PANEL ASSEMBLIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. CL WARD & Family Inc.
 2. Ductmate Industries, Inc.
 3. Flame Gard, 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 (146 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) 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. (880 g/sq. m).
 - 2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
- 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. (810 g/sq. m).
 - 2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.
 - 3. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).
- G. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
 - 1. Minimum Weight: 16 oz./sq. yd. (542 g/sq. m).
 - 2. Tensile Strength: 285 lbf/inch (50 N/mm) in the warp and 185 lbf/inch (32 N/mm) in the filling.
 - 3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).
- H. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
 - 1. Minimum Weight: 14 oz./sq. yd. (474 g/sq. m).
 - 2. Tensile Strength: 450 lbf/inch (79 N/mm) in the warp and 340 lbf/inch (60 N/mm) in the filling.
 - 3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).
- I. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outdoor 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. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch (6-mm) movement at start and stop.

2.15 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.

2.16 MATERIALS

- A. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
 1. Galvanized Coating Designation: G90
 2. Exposed-Surface Finish: Mill phosphatized.
- B. Stainless Steel Sheets: Comply with ASTM A480/A480M, Type 304, and having a No. 2 finish for concealed ducts and No.2 finish for exposed ducts.
- C. Aluminum Sheets: Comply with ASTM B209 (ASTM B209M), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, one-side bright finish for exposed ducts.
- D. Extruded Aluminum: Comply with ASTM B221 (ASTM B221M), Alloy 6063, Temper T6.
- E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.

- F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch **(10-mm)** minimum diameter for lengths longer than 36 inches (900 mm).

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 backdraft or 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.
- 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 (15-m) spacing.
 8. Upstream and downstream from turning vanes.
 9. Upstream or downstream 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. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
 2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
 3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
 4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
 5. Body Access: 25 by 14 inches (635 by 355 mm).
 6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).
- 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 (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- O. Install duct test holes where required for testing and balancing purposes.
- P. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch (6-mm) movement during start and stop of fans.
- 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

SECTION 23 33 46

FLEXIBLE DUCTS

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Flexible ducts, noninsulated.
2. Flexible ducts, insulated.
3. Flexible duct connectors.

1.2 ACTION SUBMITTALS

A. Product Data:

1. Flexible ducts, noninsulated.
2. Flexible ducts, insulated.
3. Flexible duct connectors.

B. Product Data Submittals: For each type of product.

C. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.
2. Product Data: For adhesives and sealants, indicating VOC content.

D. Shop Drawings: For flexible ducts.

1. Include plans showing locations, mounting details, and attachment details.

1.3 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.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

- A. Comply with NFPA 90A and NFPA 90B.
- 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 must be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- C. Comply with the Air Duct Council's (formerly, Air Diffusion Council) "ADC Flexible Air Duct Test Code - FD 72-R1" and "Flexible Duct Performance & Installation Standards."
- D. Comply with ASTM E96/E96M.

2.2 MANUFACTURERS

- A. Subject to meeting these specifications, products shall be:
 - 1. Thermaflex M-KC
 - 2. Flexmaster USA Type 4
 - 3. Atco Rubber Products
 - 4. Or approved equal.

2.3 FLEXIBLE DUCTS, NONINSULATED

- A. Non-Insulated, Flexible Duct: UL 181, Class 1, coated, woven fiberglass fabric supported by helically wound, spring-steel wire.
 - 1. Pressure Rating: 10-inch wg positive and 5.0-inch wg negative.
 - 2. Maximum Air Velocity: 4000 fpm.
 - 3. Temperature Range: Minus 10 to plus 160 deg F.

2.4 FLEXIBLE DUCTS, INSULATED

- A. Insulated, Flexible Duct: UL 181, Class 1, coated, woven fiberglass fabric supported by helically wound, coated galvanized spring-steel wire; fibrous-glass insulation; nylon scrim-reinforced aluminized mylar vapor-barrier film.
 - 1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
 - 2. Maximum Air Velocity: 4000 fpm.
 - 3. Temperature Range: Minus 10 to plus 160 deg F.
 - 4. Insulation R-Value: Comply with ASHRAE/IES 90.1 but not less than R-6.

2.5 FLEXIBLE DUCT CONNECTORS

- A. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.
- B. Non-Clamp Connectors: Liquid adhesive plus tape.

PART 3 - EXECUTION

3.1 APPLICATION SCHEDULE

- A. Supply air to terminal diffusers/diffuser plenums: Insulated, R6, maximum length 60 inches.
- B. Return or exhaust air: Use of flexible duct will not be acceptable.

3.2 INSTALLATION OF FLEXIBLE DUCTS

- A. Install flexible ducts according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and to the requirements of this Section, whichever is more stringent.
- B. Install in indoor applications only. Flexible ductwork should not be exposed to sunlight, fluorescent lights or other types of UV radiation.
- C. Install duct test holes in adjacent sections of sheet metal ducts where required for testing and balancing purposes.
- D. Terminate flexible ducts without exposure of any insulation or jacket edges to the airstream or to the exterior of the installation. All ends shall be rolled inward and secured by stainless steel band straps and a minimum of three (3) sheet metal screws.
- E. Installation of flexible ductwork shall only occur above readily-accessible ceilings such as grid-supported lay-in ceilings. Do not install flexible ductwork above hard ceilings such as plaster, gypsum board or architectural ceilings. This prohibition includes cloud ceilings which interfere with direct access to the flexible ductwork, end-to-end.
- F. Installation:
 - 1. Install ducts fully extended.
 - 2. Lengths shall not exceed 5'-0" (60 inches), fully-extended.
 - 3. Do not bend ducts across sharp corners.
 - 4. Bends of flexible ducting shall not exceed a minimum of ten (10) degrees total over a 5-foot length.
 - 5. Avoid contact with metal fixtures, water lines, pipes, or conduits.
 - 6. Install flexible ducts in a direct line, without sags, twists, compression or turns.
- G. Supporting Flexible Ducts:
 - 1. Suspend flexible ducts with bands or saddles 4-inches wide or wider and spaced a maximum of 24 inches apart. Maximum centerline sag between supports shall not exceed 1/2 inch per 12 inches.
 - 2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.

3. Ducts shall not rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
4. Vertically installed ducts shall be stabilized by support straps at a maximum of 16 inches o.c.

END OF SECTION 233346

SECTION 23 34 00

HVAC FANS

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fans, utility set.
2. Vehicle exhaust fan
3. Ventilators, centrifugal - roof-mounted upblast and sidewall mounted.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
 - a. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
 - b. Rated capacities, furnished specialties, and accessories for each fan.
 - c. Fans:
 - 1) Certified fan performance curves with system operating conditions indicated.
 - 2) Certified fan sound-power ratings.
 - 3) Fan construction and accessories.
 - 4) Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 5) Fan speed controllers.
 - d. Material thickness and finishes, including color charts.
 - e. Dampers, including housings, linkages, and operators.

B. Shop Drawings:

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. Include diagrams for power, signal, and control wiring.
 4. Design Calculations: Calculate requirements for selecting vibration isolators **and seismic restraints** and for designing vibration isolation bases.
 5. 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 vibration isolation, **supports, and seismic restraints** 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. Design Calculations: Calculate requirements for selecting vibration isolators, **supports, seismic restraints, and for designing vibration isolation bases.**

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans showing fan rooms and fan system layouts, reflected ceiling plans, and other drawings required to illustrate relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.
- B. Seismic Qualification Data: Certificates, for fans, 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. Startup service reports.
- D. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fans and ventilators, include the following:
 - 1. Operation in normal and emergency modes.
 - 2. Operation and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective coverage for storage and identified with labels describing contents.
 - 1. Belts: **One** set(s) for each belt-driven unit.

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 unit 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 vibration isolation, **supports, and seismic restraints**, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- F. Seismic Performance: Fans and ventilators are to withstand the effects of earthquake motions determined in accordance with **ASCE/SEI 7**. See Section 230548 "Vibration and Seismic Controls for HVAC."

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. Component Importance Factor: **1.5**

2.2 FANS, UTILITY SET

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Aerovent; a division of Twin City Fan Companies, Ltd.
 2. Greenheck.
 3. Loren Cook Company.
- B. Source Limitations: Obtain fan utility sets from single manufacturers.
- C. Description:
 1. Factory-fabricated, -assembled, -tested, and -finished, **belt**-driven centrifugal fan utility vent sets, consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.
- D. Standards: Comply with UL 705.
- E. Housings:
 1. Housing Material: **Reinforced steel**
 2. Housing Coating: **Powder-baked enamel**
 3. Formed panels to make curved-scroll housings with shaped cutoff.
 4. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 5. Discharge Arrangement: Fan scroll housing field rotatable to any of **seven** discharge positions. Provide fan with discharge positioned in proper direction to minimize connected duct turns.
- F. Wheels:
 1. Wheel Configuration: SWSI, with hub keyed to shaft.
 2. Wheel and Blade Materials: **Steel**

- a. Spark-Resistant Construction: Classified in accordance with AMCA 99, Section 8 Type B
- 3. Wheel and Blade Coating: **None**
- 4. Backward-Inclined Airfoil Blades:
 - a. Aerodynamic design.
 - b. Heavy backplate.
 - c. Hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.
- 5. Backward-Inclined Curved Blades:
 - a. Curved design.
 - b. Heavy backplate.
 - c. Single-thickness blades continuously welded at tip flange and backplate.
- 6. Backward-Inclined Flat Blades:
 - a. Flat design.
 - b. Heavy backplate.
 - c. Single-thickness blades continuously welded at tip flange and backplate.
- 7. Forward-Curved Blades:
 - a. Curved design.
 - b. Heavy backplate.
 - c. Single-thickness blades continuously welded or riveted at tip flange and backplate.
- G. Shafts:
 - 1. Turned, ground, and polished steel; keyed to wheel hub. First critical speed at least 1.4 times maximum class speed.
- H. Bearings:
 - 1. Heavy-duty regreasable ball or roller type in a cast-iron pillowblock housing.
 - 2. Ball-Bearing Rating Life: ABMA 9, **L10 of 80,000 hours**
 - 3. Roller-Bearing Rating Life: ABMA 11, **L10 of 80,000 hours**
 - 4. Extend grease fitting to accessible location outside of unit.
- I. Belt Drive:
 - 1. Factory mounted, with final alignment and belt adjustment made after installation.
 - 2. Service Factor Based on Fan Motor Size: **1.5**
 - 3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.

4. Motor Pulleys: Adjustable pitch for use with motors through **5** hp; fixed pitch for use with motors larger than **5** hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 6. Belt Guards: Comply with OSHA and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," **0.146-inch-thick, 3/4-inch (20-mm)** diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short-circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
- J. Motor Enclosure: **Totally enclosed, fan cooled**
- K. 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. Outlet Screens: Removable wire mesh.
 8. Belt Guard: OSHA-compliant, fabricated in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible." Diamond mesh wire screen welded to steel angle frame or equivalent, prime coated.
 9. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
 10. Drain Connections: NPS 3/4 (DN 20) threaded coupling drain connection installed at lowest point of housing.
 11. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.
 12. Discharge Dampers: Assembly with **parallel** blades constructed of two plates formed around, and to, shaft, channel frame, and sealed ball bearings, with blades linked outside of airstream to single control lever of same material as housing.
 13. Grease Collection Trough and Receiver: For restaurant exhaust application.
 14. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

2.3 VEHICLE EXHAUST FAN

- A. MANUFACTURERS – Plymovent STR system or approved equal by:
 - 1. Magne-Grip
 - 2. Nedereman
- B. System description: Vehicle Exhaust Rail, hose reels and drops are designed by other trades and pre-purchased by CM.
- C. Automatic Control Panel shall be Plymovent designed to:
 - 1. Automatically energize the exhaust blower by a pressure sensor, the moment any vehicle engine connected to the system is started as signaled through the BMS.
 - 2. The control panel shall contain the motor starter, overload, and solid-state circuit card with timer adjustments from 180 to 360 seconds, fused low voltage transformer, in a NEMA 12 rated key lock electrical enclosure.
 - 3. On the exterior the panel shall be soft touch AUTO START- STOP - MANUAL RUN membrane controls and system indicator LED lights.
 - 4. Panel shall require 120 volt, 1 phase power, maximum of 16 amps.
- D. Fan data shall be as scheduled on the drawings
- E. Fan shall be Class B spark resistance construction of powder coated steel housing and aluminum wheel with shaft seals.
- F. Provide with air filtration system (VEF filter) designed to reduce the diesel exhaust particulate from the exhaust blower discharge. The 20 gauge galvanized steel cabinet shall have the easy access to the filter inside and supplied with a micro fiberglass bag filter. Provide spare filters.

2.4 VENTILATORS, CENTRIFUGAL - ROOF-MOUNTED UPBLAST OR SIDEWALL MOUNTED

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Aerovent; a division of Twin City Fan Companies, Ltd.

2. Greenheck Fan Corporation.
 3. Loren Cook Company.
- B. Source Limitations: Obtain roof-mounted upblast or sidewall-mounted centrifugal ventilators from single manufacturer.
- C. Standards:
1. Comply with UL 705.
 2. Power ventilators for use with restaurant kitchen exhaust are to comply with UL 762.
- D. Configuration: Centrifugal **roof upblast** ventilator.
- E. Housing: Removable **spun aluminum** 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.
- F. Fan Wheels: Aluminum hub and wheel with backward-inclined blades; **spark-resistant construction classified in accordance with AMCA 99, Section 8, Type B**
- G. 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; minimum ABMA 9, **L10 of 100,000 hours**.
 4. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 5. Motor Pulleys: Adjustable pitch for use with motors through **5** hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than **5** hp.
 6. Fan and motor are isolated from exhaust airstream.
- H. Accessories:
1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted **outside** fan housing, factory wired through an internal aluminum conduit.
 3. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
 4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
 5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
 6. Mounting Pedestal: Galvanized steel with removable access panel.
 7. Wall Mount Adapter: Attach wall-mounted fan to wall.
- I. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: **Built-in cant and mounting flange**

2.5 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
- B. Where variable-frequency drives are indicated or scheduled, provide fan motor compatible with variable-frequency drive.

2.6 SOURCE QUALITY CONTROL

- A. **AMCA Certification for Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.**
- B. **AMCA Certification for Fan Aerodynamic Performance Ratings: Test, rate, and label in accordance with AMCA 211.**
- C. **AMCA Certification for Fan Energy Index (FEI): Test, rate, and label in accordance with AMCA 211.**
- D. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Install fans level and plumb.
- B. Disassemble and reassemble units, as required for moving to the final location, in accordance with manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.
- D. Equipment Mounting:
 - 1. Install floor-mounted fans on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Install roof-mounted fans on roof curbs or support steel. See Drawings for specific requirements.
 - 3. Unit Support: Install fans level on structural curbs. Coordinate with duct connections. **Coordinate wall penetrations and flashing with wall construction.**
 - 4. Support duct-mounted and other hanging fans directly from the building structure, using suitable hanging systems as specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
 - 5. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 6. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- E. Curb Support, Prefabricated: Rail-type wood support provided by fan manufacturer.
- F. Unit Support: Install centrifugal fans level on structural **curbs**. Coordinate with duct connections. **Coordinate wall penetrations and flashing with wall construction.**
- G. Isolation Curb Support: Install centrifugal fans on isolation curbs, and install flexible duct connectors and vibration-isolation **and seismic-control** devices.
 - 1. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

2. Comply with requirements in Section 230548.13 "Vibration Controls for HVAC."

H. Install units with adequate clearances for service and maintenance.

- I. Label fans in accordance with requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK 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. Where installing ducts adjacent to fans, allow space for service and maintenance.

3.3 PIPING CONNECTIONS

- A. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

B. Install heat tracing on all drain piping subject to freezing temperature and as indicated on Drawings. Furnish and install heat tracing in accordance with Section 230533 "Heat Tracing for HVAC Piping."

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 is to be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
2. Nameplate is to be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch (13 mm) high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.6 STARTUP SERVICE:

- A. **Engage a factory-authorized 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 ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 4. Verify that cleaning and adjusting are complete.
 5. For direct-drive fans, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.
 6. For belt-drive fans, 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.
 7. Adjust belt tension.
 8. Adjust damper linkages for proper damper operation.
 9. Verify lubrication for bearings and other moving parts.
 10. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 11. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 12. Shut unit down and reconnect automatic temperature-control operators.
 13. Remove and replace malfunctioning units and retest as specified above.

3.7 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Lubricate bearings.
- D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.8 CLEANING

- A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust.

3.9 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.**
 - 1. Fan 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.
 - 3. Fans and components will be considered defective if they do not pass tests and inspections.
 - 4. Prepare test and inspection reports.

3.10 DEMONSTRATION

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

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Worcester, MA
Construction Documents

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END OF SECTION 233400

SECTION 23 34 39

HIGH-VOLUME, LOW-SPEED FANS

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

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 high-volume, low-speed fans.

1.3 DEFINITIONS

- A. HVLS - High volume, low speed.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, furnished specialties, and accessories for each fan.
 - 2. Certified fan performance curves with system operating conditions indicated.
 - 3. Certified fan sound-power ratings.
 - 4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 5. Material thickness and finishes, including color charts.
 - 6. Fan speed controllers.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Show 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.
- C. Delegated-Design Submittal: For each HVLS fan.
 - 1. Include design calculations and details for selecting product mounting components and seismic restraints complying with performance requirements,

design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and seismic forces required to select mounting components and seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and details, drawn to scale and coordinated with each other, using input from installers of the items involved.
- B. Qualification Data:
 1. For Installer: Certificate from HVLS fan manufacturer certifying that Installer has successfully completed prerequisite training administered by manufacturer for proper installation of systems, including but not limited to, equipment, controls, and accessories indicated and furnished for installation.
- C. Seismic-Restraint Details:
 1. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 2. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 3. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
- D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For HVLS fans to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Provide certification that manufacturer complies with the most recent edition of ISO 9001.
- B. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by HVLS fan manufacturer.

1. Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, 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 five consecutive years before time of bid.
 - b. Demonstrated past experience on five projects of similar complexity, scope, and value.

1.8 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.

1.9 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of fans that fail in materials or workmanship within specified warranty period.
 1. Warranty Period:
 - a. For Motor, Including Controls: Five year(s) from date of Substantial Completion.
 - b. For Parts, Including Blades and Hub: Five year(s) from date of Substantial Completion.
 - c. For Labor: One 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 a qualified testing agency, and marked for intended location and application.
- B. UL Compliance: Listed and labeled to UL 507.
- C. CSA Compliance: Listed and labeled to CSA C22.2, No. 113.
- D. Comply with NFPA 13 requirements for HVLS fans.
- E. AMCA Compliance:
 - 1. Test HVLS fans according to AMCA 230.
 - 2. Certify HVLS fan performance according to AMCA 211.
- F. Performance Data: Comply with ANSI 230 test procedure standard, based on five rating points: 20-, 40-, 60-, 80-, and 100-percent of maximum speed. Comply with AMCA 211 for publication of performance data.
- G. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 40 00 "Quality Requirements," to design HVLS ceiling fans.
- H. Seismic Performance: HVLS ceiling fans shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the HVLS fans will remain in place without separation of any parts when subjected to the seismic forces specified and the units will be fully operational after the seismic event."
 - 2. Component Importance Factor: 1.5.

2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Big Ass Fans.
 - 2. Blue Giant Equipment Corporation.
 - 3. Envirofan
- B. Source Limitations: Obtain HVLS fans from single source from single manufacturer.

2.3 HIGH-VOLUME, LOW-SPEED FANS

- A. Description: Factory-assembled and -tested horizontal, non-ducted fan unit, consisting of large-diameter blade set, direct-drive electric motor, with variable-speed motor controller.
 - 1. Provide fan designed to circulate large air volume, vertically, at low velocity.
 - 2. Maximum Operating Temperature: 122 (50) deg F (deg C).
 - 3. Frame:
 - a. Material: Cast Iron.
 - 4. Blades: Airfoil type.
 - a. Quantity: 3.
 - b. Material: Aluminum.
 - 1) Blade Finish: Baked White Enamel.
 - 5. Motor: Totally enclosed, heavy-duty, thermally protected.
 - 6. Controls: Provide fixed manual variable speed motor controller speed control.
 - 7. Standard Mounting Bracket: Steel beam/steel angle.
 - 8. Mounting Bracket: steel beam/steel angle.
 - 9. Accessories:
 - a. Mounting extension tube.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with requirements for installation tolerances and other conditions affecting HVLS fan performance, maintenance, and operations.
 - 1. Fan locations indicated on Drawings are approximate. Determine exact locations before roughing-in for mounting, control, and electrical connections.
- B. Examine areas for suitable conditions where fan will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF HIGH-VOLUME LOW-SPEED FANS

- A. Install fan according to manufacturer's published instructions.
- B. Comply with NECA 1 and NFPA 70.
- C. Equipment Mounting:
 - 1. Anchor fan to building structure with manufacturer's recommended mounting bracket for installed condition.

2. Consult a licensed professional structural engineer for mounting methods and approval for mounting to the structure. Structure must be able to withstand the torque and forces generated by the fan.
 3. Comply with requirements for hangers and supports specified in Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment."
 4. Comply with requirements for vibration isolation and seismic-control devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC."
- D. Install unit to permit access for maintenance.
- E. Install parts and accessories shipped loose.

3.3 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 26 05 53 "Identification for Electrical Systems."
- E. Install power wiring to field-mounted electrical devices, furnished by fan manufacturer, but not factory mounted.

3.4 CONTROL CONNECTIONS

- A. Connect control wiring to field-mounted control devices.
- B. Connect control wiring according to Section 26 05 23 "Control-Voltage Electrical Power Cables."
- C. Connect control interlock wiring between HVLS fan and other equipment to provide a complete and functioning system.
- D. Install control devices furnished by manufacturer, but not factory mounted.
- E. Install control wiring to field-mounted control devices, furnished by fan manufacturer, but not factory mounted.
- F. Protect installed units from damage caused by other work.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency, Contractor Engaged: Engage a qualified testing agency to perform tests and inspections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Fan 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.
- C. Fan or components will be considered defective if fan or components do not pass tests and inspections.
- D. Prepare and submit 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 fan is secure on mountings and supporting devices and that connections to electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers and switches.
 - 3. Verify proper motor rotation direction and free fan rotation.
 - 4. Check bearing and gearbox lubrication.
 - 5. Verify proper fan rotation. Set rotation selector to blow vertically downward during heating season, and vertically upward during cooling season.

3.7 ADJUSTING

- A. Comply with requirements in Section 23 05 93 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.8 CLEANING

- A. Clean equipment externally; remove coatings applied for protection during shipping and storage, foreign material, and oily residue according to manufacturer's written instructions. Following manufacturer's cleaning procedures, and clean with manufacturer-recommended cleaning products.

3.9 DEMONSTRATION

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

END OF SECTION

SECTION 23 36 00

AIR TERMINAL UNITS

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Modulating, single-duct air terminal units.
2. Exhaust single-duct terminal units.

1.2 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. 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, seismic restraints, and vibration isolation.

C. Delegated Design Submittal: For vibration isolation and supports, , and seismic restraints 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. Materials, fabrication, assembly, and spacing of hangers and supports.
2. Design Calculations: Calculate requirements for selecting vibration isolators, supports, and seismic restraints.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, indicating the items described in this Section, and coordinated with all building trades.
- B. Seismic Qualification Data: For air terminal units, 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.

1.4 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.

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. Fan-Powered-Unit Filters: Furnish one spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a Qualified Electrical Testing Laboratory, and marked for intended location and application.
- B. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment," and Section 7 - "Construction and System Start-up."
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."
- D. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation, supports, and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- E. Seismic Performance: Air terminal units shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."
 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. Component Importance Factor: 1.5.

2.2 MODULATING, SINGLE-DUCT AIR TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North America.
 2. Johnson Controls, Inc.
 3. Price Industries Limited.

AIR TERMINAL UNITS

4. Titus; brand of Johnson Controls International plc, Global Products.
 5. Trane.
- B. Description: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.
- C. Casing: Minimum 20-gauge- thick galvanized steel.
1. Casing Liner: Comply with requirements in "Casing Liner" Article below for "Casing Liner, Fibrous Glass" Paragraph with "Antimicrobial Erosion-Resistant Coating" Subparagraph with "Perforated Metal Liner" Subparagraph.
 2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 3. Air Outlet: S-slip and drive connections, size matching inlet size.
 4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
- D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
1. Maximum Damper Leakage: AHRI 880 rated, 1 percent of nominal airflow at 3-inch wg (750-Pa) inlet static pressure.
- E. Velocity Sensors: Multipoint array with velocity inlet sensors.
- F. Attenuator Section: Casing material and thickness matching associated air terminal unit casing. Provide absorptive attenuator integral with the air terminal unit, with noise transmission loss performance as required in schedules on Drawings.
- G. Direct Digital Controls:
1. Terminal Unit Controller: Pressure-independent, controller and integrated spring-return closed actuator, and electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes.
 - a. Occupied and unoccupied operating mode.
 - b. Remote reset of airflow or temperature set points.
 - c. Adjusting and monitoring with portable terminal.
 - d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

2. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.
 3. Terminal Unit Controller, Section 230923: Controller is to be factory mounted and wired by air terminal manufacturer; unit controllers, integrated actuators, and room sensors to be furnished under Section 230923 "Direct Digital Controls (DDC) for HVAC."
- H. Control Sequence: See Section 230993.11 "Sequence of Operation for HVAC" for control sequences.

2.3 EXHAUST SINGLE-DUCT TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. ENVIRO-TEC; brand of Johnson Controls International plc, Building Solutions North America.
 2. Johnson Controls, Inc.
 3. Price Industries Limited.
 4. Titus; brand of Johnson Controls International plc, Global Products.
 5. Trane.
- B. Description: Volume-damper assembly inside unit casing with control components inside a protective metal shroud, for exhaust applications where pressurization control via exhaust and supply airflow control is desired.
- C. Casing: Minimum 20-gauge- thick galvanized steel.
1. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 2. Air Outlet: S-slip and drive connections, size matching inlet size.
 3. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
- D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
1. Maximum Damper Leakage: AHRI 880 rated, 1 percent of nominal airflow at 3-inch wg (750-Pa) inlet static pressure.

- E. Attenuator Section: Casing material and thickness matching associated air terminal unit casing. Provide absorptive attenuator integral with the air terminal unit, of noise transmission loss performance as required in schedules on Drawings.
- F. Direct Digital Controls:
 - 1. Terminal Unit Controller: Pressure-independent, controller and integrated spring-return closed actuator, and electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes.
 - a. Occupied and unoccupied operating mode.
 - b. Remote reset of airflow or temperature set points.
 - c. Adjusting and monitoring with portable terminal.
 - d. Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 - 2. Terminal Unit Controller, Section 230923: Controller is to be factory mounted and wired by air terminal manufacturer; unit controller, actuators, and room sensors are to be furnished under Section 230923 "Direct Digital Control (DDC) System for HVAC."
 - 3. Damper Actuator: 24 V, spring-return closed.
- G. Control Sequence: See Section 230993.11 "Sequence of Operation for HVAC" for control sequences.

2.4 CASING LINER

- A. Casing Liner, Fibrous Glass: Fibrous-glass duct liner, complying with ASTM C1071, NFPA 90A or NFPA 90B, and with NAIMA AH124.
 - 1. Minimum Thickness: 1 inch (25 mm).
 - a. Maximum Thermal Conductivity:
 - 1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
 - 2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F (0.033 W/m x K) at 75 deg F (24 deg C) mean temperature.

2. Antimicrobial Erosion-Resistant Coating: Apply to surface of liner that will form interior surface of duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound is to be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Perforated Metal Liner: Perforated galvanized sheet metal encapsulating matted insulation face from airstream.
4. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Comply with Section 230529 "Hangers and Supports for HVAC Piping and Equipment" and Section 233113 "Metal Ducts" for hangers and supports.
- B. Install air terminal units according to NFPA 90A.
- C. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.
- D. Install wall-mounted thermostats.

3.2 DUCTWORK CONNECTIONS

- A. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.
- B. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

3.3 ELECTRICAL CONNECTIONS

- A. Install field power to each air terminal unit electrical power connection. Coordinate with air terminal unit manufacturer and installers.
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- E. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number 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 (13 mm) high.

3.4 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."

3.5 IDENTIFICATION

- A. Label each air terminal unit with drawing designation, nominal airflow, 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.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks in accordance with 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 ADJUSTING

- A. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air terminal unit testing, adjusting, and balancing.

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: Contractor 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 the following tests and inspections with the assistance of a factory-authorized service representative:
 - 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.
- D. Air terminal unit will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.9 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 233600

SECTION 23 37 13

DIFFUSERS, REGISTERS, AND GRILLES

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions of Division 1, State of Connecticut, Department of Transportation, Standard Specifications for Roads, Bridges, Facilities, and Incidental Construction, Form 819 – 2024, and supplemental specifications thereto, shall be a part of this specification.

1.2 SUMMARY

A. Section Includes:

- 1. Rectangular and square ceiling supply air diffusers.
- 2. Rectangular and square ceiling return air and exhaust air grilles and registers.
- 3. Rectangular and square ceiling return air filter grilles.
- 4. Sidewall supply and return grilles and registers.
- 5. Linear air devices, supply diffusers and return inlets.
- 6. Shop-fabricated inlets and outlets for specific spaces.

B. Related Sections:

- 1. Section 230713 "Duct Insulation" for thermal insulation of components.
- 2. Section 233113 "Metal Ducts", for associated sheet metal plenums, acoustical duct lining and treatments, sheet metal connections and practices.
- 3. Section 233300 "Air Duct Accessories" for volume-control dampers not integral to diffusers, registers, and grilles.
- 4. Section 233346 "Flexible Ducts", for limitations on their application.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated, include the following:
 - 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. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
 - 3. The manufacturer shall provide published performance data for each diffuser or grille type. Each type shall be tested in accordance with ANSI/ASHRAE Standard 70-2006
- B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.
- C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

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.

1.5 DEFINITIONS:

- A. Air Distribution Devices: A collective and general term for all products under this Section. Specific terms such as Diffuser, Register and Grille, shall be used to distinguish specifics.
- B. Diffuser: A supply-air distributing device, usually in a ceiling application, to achieve a specific air throw pattern and distribution in the space served.

- C. Grille: A covering device for return or exhaust extract openings.
- D. Register: A grille, but with an integral volume damper.
- E. Linear: An air distribution device characterized by a narrow width relative to its length, often comprised of slots or louvers, fixed or adjustable as indicated. Linear devices can be modular of fixed lengths or continuous for a seamless appearance. Linear devices are principally supply diffusers but shall also be used for return where so designated.
- F. Louvered: A device type characterized by angled parallel blades so as to conceal direct viewing into the ductwork from one side.
- G. Supply: Air ducted to a space for purposes of heating, ventilating, cooling or air conditioning as the system provides,
- H. Return: Air extracted from a space to be recirculated.
- I. Exhaust: Air that is extracted from a space that is not to be recirculated but to be discharged to atmosphere.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR AIR DISTRIBUTION DEVICES:

- A. Color and Finish:
 - 1. All colors and finishes shall be as selected by the Architect during submittal review from factory tier-3 colors, with color chips provided during the submittal process specific to each type of device.
 - 2. Sufficient compatible touch-up paint shall be provided, not less than one pint (473 ml) per color used and an equivalent amount of appropriate solvent, if not water-based.
- B. Mounting Surface Treatments:
 - 1. Each device shall be provided with all factory trim and accessories for a complete finished installation of the product and coordinated with the Architect.
 - 2. All devices shall have edge seals to reduce air bypass and smudging on finished surfaces.

3. Devices for lay-in ceiling installations shall have a default grid-size panel with borders to match the ceiling grid used, such as flat, stepped, tegular, spine, narrow-tee or the like.
4. Devices for lay-in ceilings in small rooms where there are no full tiles to allow default grid-size panel treatments, shall be surface-mounted "cut-in" installations with face flanges. These applications are exceptions and shall be coordinated with the Architect.
5. Devices for hard-finished installations such as plaster, plaster-board, phenolic and other less-accessible surfaces shall be provided with trim frames appropriate to the surface. These shall include plaster-ground frames, fabricated external frames to allow placement in the surfaces and device installation later.
6. Linear devices shall have a continuous appearance including pre-installation frames, mitered corners, end frame terminations and edge seals. Splines and trim shall be provided to meet these requirements.
7. Where devices are installed exposed in ductwork, the duct collar outside dimension shall be equal to the device frame outside dimension for a flush appearance. "Flange-on-flange" installations shall not be acceptable.

C. Appearance in the Finished Spaces

1. Louvered return or exhaust devices shall be oriented to face toward a wall and away from the main volume of a space.

D. Duct Connections:

1. Refer to Section 233346 "Flexible Ducts", for limitations on their use.
2. Ceiling device connections (necks) are scheduled as square or round.
3. Unless the specified devices are commercially available in round-necks only, nothing shall prohibit the use of different configurations such as straight square or rectangular necks, top-plenums with side-entry of branch ducts, collars to flat horizontal ducts, all subject to review in the Duct Standards Submittal.
4. Where round duct connections are proposed, the devices shall be provided with square to round adapters.

2.2 CEILING SQUARE DIFFUSERS

A. Supply square Cone diffuser (CD-1 and CD-2)

1. Basis-of-Design Product: Subject to compliance with requirements, provide Price SCD or comparable product by one of the following:
 - a. Anemostat Products; a Mestek company.

- b. Nailor Industries Inc.
 - c. Titus.
 - d. Or Approved Equal.
- 2. Devices shall be Square Cone type, specifically designed for variable-air-volume flows with high diffusion efficiency.
 - 3. Material: Heavy gauge steel construction (Model SCD) or Aluminum (Model ASCD).
 - 4. Finish: Anodic acrylic paint, default a paintable eggshell finish, color to be selected by the architect, baked at 315°F for 30 minutes.
 - 5. Devices for lay-in ceilings shall be compatible with 24 by 24-inch modules for integration into standard ceiling grid. Devices for surface mount (drywall/plaster) shall have surface mount frames (Option F) to allow proper installation and provide a neat, finished appearance..
 - 6. Face Style: Square Cone.
 - 7. Pattern: Fixed pattern (360°/4-way, 3-way, 2-way, or 1-way) as indicated on the schedule. The core shall be one-piece stamped construction without corner joints.
 - 8. Dampers: Opposed Blade Damper (OBD) for square necks or Radial/Butterfly Damper for round necks, operable from the face of the diffuser..
 - 9. Accessories:
 - a. Equalizing grid.
 - b. Plaster frame/ring (for surface mount).
 - c. Safety chain.
 - d. Wire guard.
 - e. Directional Baffles (optional, to modify airflow pattern in the field).
 - f. Operating rod extension.
- B. Return/Exhaust Diffuser:
- 1. Basis-of-Design Product: Subject to compliance with requirements, provide Price PDR perforated face type devices in configurations as scheduled. Equivalent products will be acceptable by:
 - a. Anemostat Products; a Mestek company.
 - b. Nailor Industries Inc.
 - c. Titus.
 - d. Tuttle and Bailey

- e. Or approved Equal.
- 2. Material: 24 gauge steel back pan and 24 gauge steel face.
 - 3. Finish: Anodic acrylic paint, color to be selected by the architect, baked at 315°F for 30 minutes. Architect shall select final colors.
 - 4. Face Style: Perforated face with 3/16-inch diameter holes on 1/4-inch staggered centers (approx. 51% free area). The face shall be hinged and removable to allow access to the damper or filter (if applicable).
 - 5. Frame: Designed for integration into the specified ceiling system.
 - 6. Mounting Frame:
 - a. Lay-in: Compatible with 24 by 24-inch (or as scheduled) ceiling grid.
 - b. Surface-mount: Countersunk screw holes in the frame (if applicable).
 - 7. Damper Type: Heavy gauge steel Opposed Blade Damper (OBD), operable from the face of the diffuser (requires opening the hinged face).
 - 8. Face Size: Refer to schedule.
 - 9. Duct Inlet: Refer to schedule.
 - 10. Accessories:
 - a. Plaster ring.
 - b. Safety chain.
 - c. Filter rack.
- C. Filter Return Grilles:
- 1. Basis-of-Design Product: Subject to compliance with requirements, provide Price 500 louvered devices in configurations as scheduled. Equivalent products will be acceptable by:
 - a. Anemostat Products; a Mestek company.
 - b. Nailor Industries Inc.
 - c. Titus.
 - d. Tuttle and Bailey
 - e. Or approved Equal.
 - 2. Material: Roll-formed Steel construction. 24 gauge steel borders and blades.
 - 3. Finish: Anodic acrylic paint, color to be selected by the architect, baked at 315°F for 30 minutes. Architect shall select final colors.
 - 4. Face Size: 24 by 24-inch lay-in grid or equivalent square for non-grid ceilings. Hinged on one-side for lowering and provided with a safety chain to limit

- initial drop to that required to extract and replace the filter. Chain shall have a secure hook to allow full-arc opening for duct inspection and cleaning.
5. Hardware: Positive quarter-turn screws and latches for secure/non-public spaces. Positive quarter-turn screws and latches with snake-eye hardware for public-access areas including tenant space.
 6. Face Blade Arrangement: Horizontal spaced 3/4 inches apart.
 7. Face Blade Deflection: 35° or 0° fixed.
 8. Frame:
 - a. Lay-in: Compatible with 24 by 24-inch ceiling grid.
 - b. Surface Mount: 1-1/4 inches wide border with countersunk screw holes.
 9. Duct Inlet: Square-only to maximize filter surface exposure.
 10. Accessories:
 - a. Plaster frame.
 - b. Safety chain.
 - c. Concealed hardware

2.3 CEILING LINEAR DEVICES

A. Linear Slot Diffuser SL-#, RL-# and EL-#.

1. Basis-of-Design Product: Subject to compliance with requirements, provide products as follows:
2. PRICE SDS, SDB or comparable product by one of the following:
 - a. Anemostat Products; a Mestek company.
 - b. Nailor Industries Inc.
 - c. Titus.
 - d. Or Approved Equal.
3. Devices shall be Price Model SDS, specifically designed for variable-air-volume flows with high induction ratios.
4. Material - Shell: Extruded Aluminum with spring steel retainers.
5. Material - Pattern Controller: Formed Steel pattern controllers (Ice-tong type).
6. Finish - Flanges: exposed to view shall be painted factory white or as directed by the Architect.
7. Finish - Pattern Controllers: Black (Standard) to match the internal surfaces and provide a "shadow" appearance, or as selected by the architect.
8. Frame style: Clip and hanger support system shall be selected to be integrated with the ceiling type.
9. Slot Width: refer to schedule.

10. Number of Slots: refer to schedule.
11. Length: Continuous per plans.
12. Accessories: Provide all materials and equipment required for a complete installation of all linear air distribution systems as shown on the architectural and mechanical drawings and indicated in the specification and shall include all required appurtenances.
 - a. Provide end and corner pieces as required.
 - b. The Mechanical contractor shall provide plenums, blank-offs and associated sheet metal components including all duct connections. Note that plenums per the drawings exceed those provided by the manufacturer as standard and shall be provided by the DIV 23 Sheet Metal Subcontractor.
 - c. Plenums shall be minimum 24-gauge galvanized steel and lined inside with minimum one-inch black matte insulation.

2.4 REGISTERS AND GRILLES

A. Spiral Duct Grilles CD-3, EF-6, EG-7.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Price SDG, a double-deflection supply register or comparable product by one of the following:
 - a. Nailor Industries Inc.
 - b. Titus.
 - c. Tuttle and Bailey
 - d. Or approved equal.
2. Devices shall be Spiral Duct Grille type (Price Model SDG), specifically designed for direct mounting on round spiral ducts.
3. Material: Steel.
4. Finish: Baked enamel, color to be selected by the architect.
5. Frame: 1-1/4 inches wide border, curved to conform to the diameter of the spiral duct.
6. Gasket: Provide with foam gasketing along the borders to prevent air leakage between the grille and the duct radius.
7. Face Blade Arrangement: Double Deflection.
8. Front Blades: Vertical, adjustable, spaced 3/4 inches apart to control the spread (throw). (Note: Vertical front blades are standard for spiral ducts to spread air along the length of the room).

9. Rear Blades: Horizontal, adjustable, to control the drop/rise.
 10. Mounting: Countersunk screw holes on the face.
 11. Damper / Extractor (Critical):
 - a. For Supply Air: Provide with adjustable Air Scoop / Extractor (Model V or S) to capture air from the high-velocity duct stream and direct it into the grille. Operable from the face (screwdriver slot).
 - b. For Return Air: Heavy gauge steel Opposed Blade Damper (OBD).
 12. Sizing: Grille curvature shall be matched to the specific duct diameter shown on drawings.
- B. Sidewall Grilles EG-1, EG-2.
1. Basis-of-Design Product: Subject to compliance with requirements, provide Price 530, a louver grille or comparable product by one of the following:
 - a. Nailor Industries Inc.
 - b. Titus.
 - c. Tuttle and Bailey
 - d. Or approved equal.
 2. Material: Roll-formed Steel construction. 24 gauge steel borders and blades.
 3. Finish: Baked enamel, color to be selected by the architect.
 4. Face Blade Arrangement: Horizontal spaced 3/4 inches apart.
 5. Face Blade Deflection: Fixed at 35° deflection.
 6. Frame: 1-1/4 inches wide border.
 7. Gasket: Provide with sponge foam gasketing on the back of the frame to prevent air leakage and smudging.
 8. Mounting Frame: Surface mount.
 9. Mounting: Countersunk screw holes on the face.
 10. Damper Type: Heavy gauge steel opposed blade damper, operable from the face of the grille.
- C. Ring Nozzle Diffuser CD-4.
1. Basis-of-Design Product: Subject to compliance with requirements, provide Price AND, a louver grille or comparable product by one of the following:
 - a. Nailor Industries Inc.
 - b. Titus.
 - c. Tuttle and Bailey

- d. Or approved equal.
- 2. Devices shall be Adjustable Nozzle type (Price Model AND), specifically designed for spot heating/cooling or long-throw applications
- 3. Material: Heavy Gauge Spun Aluminum construction.
- 4. Finish: Baked enamel, color to be selected by the architect.
- 5. Nozzle Adjustment:
 - a. The nozzle shall be capable of +/- 30 to 38 degrees of directional adjustment in any direction (omnidirectional) from the centerline.
 - b. The adjustment mechanism shall be smooth and hold its position without the need for locking screws or tools.
- 6. Construction: The nozzle assembly shall consist of a spun aluminum outer shell and a spun aluminum inner nozzle core with a spherical mounting to allow rotation.
- 7. Mounting Type: Type P (Panel Mounted): Nozzle mounted in a square steel or aluminum panel to fit surface mount.
- 8. Damper Type: Heavy gauge steel opposed blade damper.

2.5 SHOP AND FIELD-FABRICATED INSTALLATIONS:

- A. Per the drawings, provide shop-fabricated constructions including framed wire-mesh screens ("WMS") for open-ended ducts, hoods, cowls and other means of air distribution adapted to field conditions.
- B. All fabrications shall be constructed per SMACNA and per submitted and reviewed Sheet Metal Shop Standards and to match the duct material in which they are installed. No sharp edges shall be permitted. All such devices shall be screw-removable to allow cleaning and inspection.
- C. All open-ended ducts shall be covered with 1/2-inch WMS for vermin control and to catch any duct debris. Frames shall be fully-hemmed. Where indicated, ducts shall be cut at 45-degrees to provide greater free-area than a flat-end.
- D. Where installed in building surfaces, the devices shall be flush-mounted to the substrate into backing sheet metal flanges.

2.6 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers, registers, and grilles 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, registers, and grilles are to be 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 diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: 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 diffusers, registers, and grilles 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 diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713

SECTION 23 72 23.29

PACKAGED, OUTDOOR, FIXED PLATE ENERGY RECOVERY UNITS

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Packaged, outdoor, fixed-plate, sensible heat, energy-recovery units.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of product.
 - a. Include packaged, outdoor, fixed-plate, energy-recovery-unit rated capacities, operating characteristics, furnished specialties, and accessories.
 - b. Energy core performance data for both summer and winter operation.
 - c. Motor ratings, electrical characteristics and motor and fan accessories.
 - d. Material types and gauges of all component pieces and assemblies.
 - e. Dimensioned drawings for each type of installation, showing isometric and plan views, to include location of attached ductwork and service clearance requirements.
 - f. Estimated gross weight of each installed unit.
 - g. Installation, Operating and Maintenance manual (IOM) for each model.
 - h. Fans:

- 1) Certified fan-performance curves with system operating conditions indicated.
 - 2) Certified fan-sound power ratings.
 - 3) Fan construction and accessories.
 - 4) Motor ratings, electrical characteristics, and motor accessories.
- B. Shop Drawings: For packaged, outdoor, fixed-plate, energy-recovery units.
1. Include plans, elevations, sections, details, and mounting details.
 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, lifting requirements, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Include diagrams for power, signal, and control wiring.
- C. Delegated Design Submittal: For air-to-air energy-recovery equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by qualified professional engineer responsible for their preparation.
1. Detail fabrication and assembly of air-to-air energy-recovery equipment.
 2. Vibration-Isolation Roof Curb Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include rails and frames for equipment mounting.
 3. Design Calculations: Calculate requirements for selecting vibration isolators, seismic restraints, and for designing vibration-isolation bases.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, roof plans, elevations, and other details, drawn to scale. and coordinated with each other, using input from installers of items involved.
- B. Seismic Qualification Data: Certificates, for packaged, outdoor, fixed-plate, energy-recovery units, 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 certification is based and their installation requirements.

- C. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For packaged, outdoor, fixed-plate, energy-recovery equipment to include in maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed. Package with protective covering for storage and identify 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.

1.6 COORDINATION

- A. Coordinate size and location of all building penetrations required for installation of each unit and associated plumbing and electrical systems.
- B. Coordinate sequencing of construction of associated plumbing, HVAC, electrical supply.

1.7 QUALITY ASSURANCE

- A. Source Limitations: Obtain unit with all appurtenant components or accessories from a single manufacturer.
- B. For the actual fabrication, installation, and testing of work under this section, use only thoroughly trained and experienced workers completely familiar with the items required and with the manufacturer's current recommended methods of installation.

- C. Product Options: Drawings must indicate size, profiles and dimensional requirements of Energy Recovery Units and are to be based on the specific system indicated. Refer to Division 1 Section "Product Requirements".
- D. Certifications:
 - 1. Entire unit shall be ETL Certified per U.L. 1812 and bear an ETL sticker.
 - 2. Energy Core shall be AHRI Certified, per Standard 1060.

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of packaged, outdoor, fixed-plate, energy-recovery units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Packaged Energy-Recovery Units: Two years date of Substantial Completion.
 - 2. Warranty Period for Fixed-Plate Heat Exchangers: Five years from date of Substantial Completion.

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. Delegated Design: Engage registered professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration-isolation controls and seismic restraints, including comprehensive engineering analysis using performance requirements and design criteria indicated.

- E. Seismic Performance: Packaged, outdoor, fixed-plate, energy-recovery units shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.
- F. Effectiveness: 65 percent in winter.

2.2 PACKAGED, OUTDOOR, FIXED-PLATE, SENSIBLE HEAT, ENERGY-RECOVERY UNITS

- A. Available Manufacturers: Subject to compliance with specifications contained within this document, manufacturers offering products that may be incorporated into the work include, but are not limited to:
 - 1. Valent Air Corporation
 - 2. Greenheck
 - 3. Mitsubishi
- B. Source Limitations: Obtain packaged, outdoor, fixed-plate, energy-recovery units from single manufacturer. Unit shall be fully assembled at the factory and consist of an insulated metal cabinet, outdoor air intake weatherhood with metal mesh filters, energy core, motorized intake damper, frost control, bypass damper, filter assembly for intake and exhaust air, supply air blower assembly, exhaust air blower assembly and an electrical control center. All specified components and internal accessories factory installed and tested and prepared for single-point high voltage connection.
- C. Surfaces in Contact with Airstream: Comply with requirements in ASHRAE 62.1.
- D. Cabinet:
 - 1. Materials: Formed double wall insulated metal cabinet, fabricated to permit access to internal components for maintenance.
 - 2. Outside casing: 18 gauge, galvanized (G90) steel meeting ASTM A653 for components that do not receive a painted finish. Pre-painted components as supplied by the factory shall have polyester urethane paint on 18 gauge G60 galvanized steel.
 - 3. Access doors shall be hinged.
 - 4. Cabinet Insulation: Comply with NFPA 90A and NFPA 90B and erosion requirements of UL 181.
 - 5. Materials: Fiberglass insulation. If insulation other than fiberglass is used, it must also meet the Fire Hazard Classification shown below.
 - 6. Thickness: 1 inch (25 mm)
 - 7. Fire Hazard Classification: Maximum flame spread of 25 and smoke developed of 50, when tested in accordance with ASTM C 411.

8. Location and application: Full coverage of entire cabinet exterior to include walls, roof and floor of unit. Insulation shall be of semi-rigid type and installed between inner and outer shells of all cabinet exterior components.
9. Supply Air and Exhaust Air blower assemblies: Blower assemblies consist of an electric motor and a direct driven blower. Assembly shall be mounted on heavy gauge galvanized rails and further mounted on 1.125 inch thick neoprene vibration isolators.
10. Control panel / connections: Energy Core Ventilator shall have an electrical control center where all high and low voltage connections are made. Control center shall be constructed to permit single-point high voltage power supply connections.
11. Frost control: timed exhaust.
12. Economizer Control: Bypass Damper
13. Motorized dampers / Intake Air, Motorized dampers of low leakage type shall be factory installed.

E. Blower section:

1. Blower section construction, Supply Air and Exhaust Air: Direct drive motor and blower shall be assembled with neoprene vibration isolation devices.
2. Blower assemblies: Shall be statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and horsepower.
3. Centrifugal blower housing: Formed and reinforced steel panels to make curved scroll housing with shaped cutoff.
4. Forward curved blower (fan) wheels: Galvanized or aluminum construction with inlet flange and shallow blades curved forward in direction of airflow. Mechanically attached to shaft with set screws.
5. Blower performance shall be factory tested for flow rate, pressure, power, air density, rotation speed and efficiency. Ratings are to be established in accordance with AMCA 210, "Laboratory Methods of Testing Fans for Rating".

F. Motors:

1. General: Blower motors greater than 3/4 horsepower shall be "NEMA Premium" unless otherwise indicated. Minimum compliance with EPA's minimum energy-efficiency standards for single speed ODP and TEFC enclosures is not acceptable. Motors shall be heavy-duty, permanently lubricated type to match the fan load and furnished at the specified voltage, phase and enclosure.
2. Fan motors shall be 60 cycle, 1 phase 115 volts.

G. Unit controls:

1. The unit shall be constructed so that it can be controlled by factory-supplied controllers, thermostats and sensors or it can be monitored and controlled by a Building Management System (BMS).
2. Sensors
 - a. Dirty filter sensor

H. Filters:

1. Unit shall have permanent metal filters located in the outdoor air intake and shall be accessible from the exterior of the unit. MERV 8 disposable pleated filters shall be provided in the intake air stream and MERV 8 filters in the exhaust air stream.

2.3 SOURCE QUALITY CONTROL

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by 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 (IP) (AHRI 1061 [**SI**]).
- 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 in accordance with AMCA 210 and ASHRAE 51.
- D. Fan Sound Ratings: Comply with AMCA 301 or AHRI 260 (IP) (AHRI 261 [**SI**]).
- E. UL Compliance:
 1. Packaged, Fixed-Plate, Energy-Recovery Units: Comply with requirements in UL 1812.
 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, outdoor, fixed-plate, energy-recovery unit installation. Replace 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 OF PACKAGED, OUTDOOR, FIXED-PLATE, ENERGY-RECOVERY UNITS

- A. Install packaged, outdoor, 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. Equipment Mounting:
 - 1. Install packaged, outdoor, fixed-plate, energy-recovery units on 4-inch (100-mm) cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Install roof-mounted packaged, outdoor, fixed-plate, energy-recovery units on manufacturer's-recommended-height equipment roof curbs. Comply with requirements for equipment curbs specified in Section 077200 "Roof Accessories."
 - 3. Comply with requirements for vibration-isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

PACKAGED, OUTDOOR, FIXED PLATE ENERGY RECOVERY UNITS

- 4. Comply with requirements for vibration-isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Suspended Units: Suspend and brace units from outdoor structural-steel support frame, using threaded steel rods and spring hangers. Comply with requirements for vibration-isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- D. Install units with clearances for service and maintenance.
- E. Do not operate equipment fans until temporary or permanent filters are in place. Replace temporary filters used during construction and testing with new, clean filters prior to final inspection.

3.3 DUCTWORK CONNECTIONS

- A. Comply with requirements for ductwork in accordance with Section 233113 "Metal Ducts."
- B. Connect duct to units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."
- C. Isolation Dampers: Install isolation dampers in accordance with Section 230923.12 "Control Dampers."

3.4 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to unit, allow for service and maintenance.
- C. Connect piping to units mounted on vibration isolators with flexible connectors.

- D. Condensate Drain Piping: See Section 232113 "Hydronic Piping" for pipe type. Install condensate drain piping from drain pans to nearest floor drain, same size as condensate drain connection.
 - 1. Construct deep trap at connection to drain pan, and install cleanouts at changes in direction.

3.5 ELECTRICAL CONNECTIONS

- A. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number 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 (13 mm) high.

3.6 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."

3.7 STARTUP SERVICE

- A. Engage factory-authorized service representative to perform startup service.

1. Complete installation and startup checks in accordance with 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 FIELD QUALITY CONTROL

- A. Testing Agency:
 1. Owner will engage a qualified testing agency to perform tests and inspections.
 2. Engage qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections with assistance of 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, outdoor, fixed-plate, energy-recovery units will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.10 DEMONSTRATION

- A. Engage a factory authorized service representative to train owner's maintenance personnel to adjust, operate and maintain the entire unit. Refer to Division 01 Section Closeout Procedures and Demonstration and Training.

END OF SECTION 237223.29

SECTION 23 74 33

DEDICATED OUTDOOR-AIR UNITS

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Packaged, outdoor, fixed-plate, sensible heat, energy-recovery units.
2. Packaged, outdoor, heat-wheel, energy-recovery units.

B. Related Requirements:

1. Section 283111 - digital, addressable fire-alarm system
2. Section 232923 - Variable-frequency motor controllers
3. Section 230513 - Common motor requirements for HVAC equipment
4. Section 230923 - Direct Digital Control (DDC) system for HVAC

1.2 DEFINITIONS:

- A. ECM:** Electronically commutated motor.
- B. ISCOP:** Integrated Seasonal Coefficient of Performance.
- C. ISMRE:** Integrated Seasonal Moisture Removal Efficiency.
- D. MRC:** Moisture Removal Capacity.

1.3 ACTION SUBMITTALS

A. Product Data: For each dedicated outdoor-air unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
3. Include unit dimensions and weight.
4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
5. 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.
6. Include certified coil-performance ratings with system operating conditions indicated.
7. Include filters with performance characteristics.
8. Include heat exchangers with performance characteristics.
9. Include dampers, including housings, linkages, and operators.
10. Unit accessories including (but not limited to): filter gauges, access doors & windows, latches, lights, GFI outlets, drain pans, and vibration isolation.
11. Sound power levels by octave band for air handling units at scheduled design conditions. Provide sound power levels for discharge, inlet and cabinet sound paths in accordance with AMCA 300 (or ASHRAE 68) and AMCA 301.
12. Clearly define any exception made to the Plans and Specification. Contractor is responsible for any expenses that occur due to exceptions made.
13. Unit accessories including (but not limited to): filter gauges, access doors & windows, latches, lights, GFI outlets, drain pans, and vibration isolation.
14. Clearly define any exception made to the Plans and Specification. Contractor is responsible for any expenses that occur due to exceptions made.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.
2. Product Data: For air filtration performance.
3. Product Data: For adhesives, mastics, and sealants, indicating VOC content.

4. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.
 5. Product Data: For refrigerants, indicating compliance with refrigerant management practices.
- C. Shop Drawings: For each dedicated outdoor-air unit.
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. The size and location of the control, VFD, and piping enclosures are to be coordinated by the mechanical contractor and the manufacturer prior to the submission of shop drawings.
 4. Prepare the following by or under the supervision of a qualified professional engineer:
 - a. Include diagrams for power, signal, and control wiring.
- D. Delegated Design Submittal: For dedicated outdoor-air-unit supports indicated to comply with performance and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. Include design calculations for selecting vibration isolators wind restraints, and for designing vibration isolation bases.
 2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor 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. Mechanical-room layout and relationships between components and adjacent structural and mechanical elements.
 2. Support location, type, and weight.
 3. Field measurements.

- B. Sample Warranty: For manufacturer's warranty.
- C. Seismic Qualification Data: Certificates, for dedicated outdoor-air units, accessories, and components, from manufacturers.
 - 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. Restraint of internal components.
- D. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force 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.
- E. Source quality-control reports.
- F. Startup service reports.
- G. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For dedicated outdoor-air 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. Fan Belts: One set for each belt-driven fan.
 - 2. Filters: One set for each air-handling unit.
 - 3. Gaskets: One set for each access door.

1.7 WARRANTY

- A. Warranty: Manufacturer agrees to replace components of dedicated outdoor-air units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Dedicated Outdoor-Air-Handling Units: Two years from date of Substantial Completion.
 - 2. Warranty Period for Compressors: Five years from date of Substantial Completion.
 - 3. Warranty Period for Heat Exchangers: Five years from date of Substantial Completion.
 - 4. Warranty Period for Rotary Heat Exchangers: Five years from date of Substantial Completion.

1.8 QUALITY ASSURANCE

- A. Source Limitations: Obtain unit with all appurtenant components or accessories from a single manufacturer.
- B. For the actual fabrication, installation, and testing of work under this section, use only thoroughly trained and experienced workers completely familiar with the items required and with the manufacturer's current recommended methods of installation.
- C. Product Options: Drawings must indicate size, profiles and dimensional requirements of unit and are to be based on the specific system indicated. Refer to Division 1 Section "Product Requirements".
- D. End of line test with full report available upon request.

E. Certifications

1. Entire unit shall be ETL Certified per U.L. 60335-2-40 and bear an ETL sticker.
2. Energy Recovery Device shall be AHRI Certified, per Standard 1060.

F. Comply with NFPA 70.

G. ANSI/ABMA 9 - Load Ratings and Fatigue Life for Ball Bearings.

H. ANSI/ABMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

I. SMACNA - HVAC Duct Construction Standards.

J. ARI Compliance: All coils shall be certified in accordance with ARI Standard 410 for water.

K. ANSI/UL 900 - Test Performance of Air Filter Units.

L. ASTM E 84-05 - Standard Test Method for Surface Burning Characteristics of Building Materials

M. ASTM C916 - Standard Specification for Adhesives for Duct Thermal Insulation

N. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)

O. UL 181 - UL Standard for Safety Factory-Made Air Ducts and Connectors

P. UL 723 - UL Standard for Safety Test for Surface Burning Characteristics of Building Materials

Q. Sound power levels shall be in accordance with AMCA 300 - Reverberant Method for Sound Testing of Fans.

R. Sound power levels shall be in accordance with AMCA 301 - Method for Publishing Sound Ratings for Air Moving Devices.

DEDICATED OUTDOOR-AIR UNITS

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- S. Sound power levels shall be in accordance with ASHRAE 68 - Laboratory Method of Testing In-Duct Sound Power Measurement Procedure for Fans.
- T. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
- U. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
- V. ARI 260 - Sound Rating of Ducted Air Moving and Conditioning Equipment.

1.9 COORDINATION

- A. Coordinate size and location of all building penetrations required for installation of each unit and associated plumbing and electrical systems.
- B. Coordinate location of water system fittings to ensure correct positioning for connection to the water coil and condensate drain pipe.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an "NRTL" (nationally recognized testing laboratory), and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of 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 15 and ASHRAE 34 Compliance: For refrigeration system safety.
- E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

- F. ASHRAE 84 Compliance: Comply with capacity ratings for heat-wheel and fixed plate energy-recovery equipment.
- G. UL Compliance:
 - 1. Electric Coils: Comply with requirements in UL 1995.
- H. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation and wind restraints.
- I. Seismic Performance: Units shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7. See Section 230548 "Vibration and Seismic Controls for HVAC."
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified."

2.2 PACKAGED, OUTDOOR, FIXED-PLATE, SENSIBLE HEAT, ENERGY-RECOVERY UNITS

- A. Available Manufacturers: Subject to compliance with specifications contained within this document, manufacturers offering products that may be incorporated into the work include, but are not limited to:
 - 1. Valent Air Corporation, LLC
 - 2. Greenheck
 - 3. Trane
- B. Source Limitations: Obtain packaged, outdoor, fixed-plate, energy-recovery units from single manufacturer. Unit shall be fully assembled at the factory and consist of an insulated metal cabinet, exhaust air blower, energy core, hot gas reheat coil, air-source heat pump, motorized dampers, filter assembly intake air, supply air blower assembly, exhaust/relief blower assembly, filter assembly for exhaust air, and an electrical control center. All specified components and internal accessories factory installed are tested and prepared for single-point high voltage connection except with electric post heat and exhaust fan only power which have dual point power.
- C. Surfaces in Contact with Airstream: Comply with requirements in ASHRAE 62.1.
- D. Cabinet:

1. Cabinet Insulation: Comply with NFPA 90A and NFPA 90B and erosion requirements of UL 181.
 - a. Materials: Rigid urethane injected foam. Foam board not acceptable.
 - 1) Thickness: 2 inch (50.8 mm)
 - 2) Thermal Resistance R13
 - 3) Thermally broken
 - 4) Meets UL94HF-1 flame requirements.
 - 5) Location and application: Full coverage of entire cabinet exterior to include walls, roof of unit, unit base, and doors.
 - b. Materials: Fiberglass insulation. If insulation other than fiberglass is used, it must also meet the Fire Hazard Classification shown below.
 - 1) Thickness: 2 inch (50.8 mm)
 - 2) Thermal Resistance R8
 - 3) Fire Hazard Classification: Maximum flame spread of 25 and smoke developed of 50, when tested in accordance with ASTM C 411.
 - 4) Location and application: Divider panels between outdoor air and return air/exhaust air streams.
2. Roof Insulation: 2 inch (50.8 mm) fiberglass located above the 1 inch (25.4 mm) foam panel.

E. Housing:

1. Access panels / doors: Unit shall be equipped with insulated, hinged doors or removable access panels to provide easy access to all major components. Doors and access panels shall be fabricated of 18 gauge galvanized G90 steel or painted galvanized steel.

F. Supply and Exhaust Fans:

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
2. Motor Sizes: Minimum size as indicated. If size is not indicated, provide motor large enough so driven load will not require motor to operate in service factor range above 1.0.

3. Supply Air blower assemblies: Blower assembly shall consist of an electric motor and direct-drive fans. Assembly shall be mounted on heavy gauge galvanized steel rails and further mounted on 1.125 inch thick neoprene vibration isolators. Blower motors shall be capable of continuous speed modulation and controlled by a VFD.
4. Exhaust Air blower assemblies: Blower assembly shall consist of an electric motor and a direct-drive fan. Assembly shall be mounted on heavy gauge galvanized steel rails and further mounted on 1.125 inch thick neoprene vibration isolators. Blower motor shall be capable of continuous speed modulation and controlled by a VFD.

G. Connections:

1. Control panel / connections: Units shall have an electrical control center where all high and low voltage connections are made. Control center shall be constructed to permit single-point high voltage power supply connections. RTU shall be equipped with a Unit Disconnect Switch. Electric heater shall have single point power.
2. Condensate drain pan: Drain Pan shall be an integral part of the unit whenever a cooling option is included. Pan shall be formed of welded austenitic stainless steel sheet material and provided with a welded stainless steel drain connection at the front for connection to a P trap. Drain pan shall be sloped in two directions to provide positive draining and drain connector shall be sealed at penetration through cabinet wall.
3. P trap: If the unit is equipped with a condensate drain pan, contractor shall provide, or fabricate, and install an appropriate P trap, in accordance with all local and area codes and Best Practices.

H. Heating and Cooling:

1. Core Frost Control: Electric Preheat: Shall be provided for frost control of the energy core. Preheater assembly shall include an outdoor air temperature sensor to initiate frost control sequence. Preheater shall comply with UL 1995 and be constructed on a galvanized steel frame.
2. Reheat coil with factory installed modulating hot gas reheat valve.
3. Electric Post-heater: Post-heater shall be SCR control and shall include a temperature sensor with field adjustable set point, located in the outdoor air stream. Heat output of the post-heater shall be infinitely variable. Electric post-heater shall be able to simultaneously operate with the air-source heat pump.

4. Air-Source Heat Pump: Unit shall have an integral compressor(s) and indoor coil located within the weather-tight unit housing. Outdoor coils and appurtenant outdoor fan assemblies shall be factory installed as integral subassemblies of the unit and mounted on the exterior of the unit. Lead fan(s) will have an electronically commutated (EC) motor that will modulate to maintain a refrigerant pressure set point.] Motors shall be UL Recognized and CSA Certified. The lead refrigerant compressor shall be inverter hermetic scroll-type. Additional compressor shall be single stage hermetic scroll-type paired in tandem with lead inverter compressor. Compressors shall be equipped with liquid line filter drier, individual sight glass for heating and cooling operation, electronic expansion valves (EEV), manual reset high pressure and low pressure cutouts and all appurtenant sensors, service ports, leak detection sensors and safety devices. Compressed refrigerant system shall be fully charged with R-454B refrigerant. Each compressor shall be factory-equipped with an electric crankcase heater to boil off liquid refrigerant from the oil. Air Source Heat Pump shall be capable of delivering 100% of heat at scheduled winter design ambient without needing to run supplemental heating.
 5. Condenser Fans: Fan blades must be constructed of aluminum or a composite material and have a geometry designed and documented to reduce sound and energy when compared to a traditional rectangular blade fan. Traditional rectangular blade fans are not allowed due to increased noise generated and increase power utilized. Condenser fan motors shall be three phase, external rotor, type 56 frame, open air over and shaft up. Each condenser fan motor shall have a vented frame, rated for continuous duty and be equipped with an automatic reset thermal protector. Lead condenser fan(s) will have an electronically commutated (EC) motor that will modulate to maintain a head pressure set point.] Motors shall be UL Recognized and CSA Certified. Single condenser fan running at max RPM and design static pressure shall not exceed an A-weighted sound power level of 75 db at free inlet/outlet test conditions.
 6. Motorized dampers / Intake Air, Motorized dampers of low leakage type shall be factory installed.
- I. Blowers:
1. Blower section construction, Supply Air: direct drive motor and blower shall be assembled on a 14 gauge galvanized steel platform and shall be equipped with 1.125 inch thick neoprene vibration isolation devices.
 2. Blower assemblies: Shall be statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and horsepower.

3. Fan: Direct drive, airfoil plenum fan with steel wheel statically and dynamically balanced. Prop or belt-drive fan not acceptable due to low static capabilities.
 4. Blades: Painted steel blades only.
 5. Blower section motor source quality control: Blower performance shall be factory tested for flow rate, pressure, power, air density, rotation speed and efficiency. Ratings are to be established in accordance with AMCA 210, "Laboratory Methods of Testing Fans for Rating".
- J. Motors:
1. General: Blower motors greater than 1/2 horsepower shall be "NEMA Premium" unless otherwise indicated. Compliance with EPA's minimum energy-efficiency standards for single speed ODP and TE enclosures is not acceptable. Motors shall be heavy-duty, permanently lubricated type to match the fan load and furnished at the specified voltage, phase and enclosure.
 2. Motors shall be 60 cycle, 3 phase 460 volts.
- K. Filters, particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
- L. Filters:
1. Unit shall have permanent 2 inch (50.8 mm) aluminum filters located in the outdoor air intake and shall be accessible from the exterior of the unit. MERV 8 disposable pleated filters shall be provided in the supply air stream. MERV 8 and MERV 13 disposable pleated filters shall be provided in the supply final air stream and MERV 8 filters in the exhaust air stream.
- M. Controls:
1. The unit shall be constructed so that it can function as a stand-alone heating and cooling system controlled by factory-supplied controllers, thermostats and sensors or it can be operated as a heating and cooling system controlled by a Building Management System (BMS). This unit shall be controlled by a factory-installed microprocessor programmable controller (DDC) that is connected to various optional sensors.
 2. Unit shall incorporate a DDC controller with integral LCD screen that provides text readouts of status. DDC controller shall have a built-in keypad to permit operator to access read-out screens without the use of ancillary equipment,

devices or software. DDC controllers that require the use of equipment or software that is not factory-installed in the unit are not acceptable. Alarm readouts consisting of flashing light codes are not acceptable. Owner-specified ventilating conditions can be input by means of pushbuttons.

3. Unit supply fan shall be configured for Constant Volume (ON/OFF).
4. Unit exhaust fan shall be configured for building pressure by factory.
5. Outside Air / Return Air damper control shall be
6. Economizer control shall be temperature.
7. Variable Frequency Drive (VFD): unit shall have factory installed variable frequency drive for modulation of the supply and exhaust air blower assemblies. The VFD shall be factory-programmed for unit-specific requirements and shall not require additional field programming to operate.
8. Airflow monitoring required in the supply, and exhaust airstreams.
9. Unit shall be provided with a space thermostat measuring temperature.
10. Secondary heating source shall be capable of simultaneous operation with the air-source heat pump.

2.3 PACKAGED, OUTDOOR, HEAT-WHEEL, ENERGY-RECOVERY UNITS

- A. Available Manufacturers: Subject to compliance with specifications contained within this document, manufacturers offering products that may be incorporated into the work include, but are not limited to:
 1. Valent Air Corporation, LLC
 2. Greenheck
 3. Trane
- B. Source Limitations: Obtain packaged, outdoor, fixed-plate, energy-recovery units from single manufacturer. A. Unit shall be fully assembled at the factory and consist of an insulated metal cabinet, exhaust air blower, energy wheel, hot gas reheat coil, air-source heat pump, motorized dampers, filter assembly intake air, supply air blower assembly, exhaust/relief blower assembly, filter assembly for exhaust air, and an electrical control center. All specified components and internal accessories factory installed are tested and prepared for single-point high voltage connection except with electric post heat and exhaust fan only power which have dual point power.
- C. Surfaces in Contact with Airstream: Comply with requirements in ASHRAE 62.1.

D. Cabinet:

1. Cabinet Insulation: Comply with NFPA 90A and NFPA 90B and erosion requirements of UL 181.
 - a. Materials: Rigid urethane injected foam. Foam board not acceptable.
 - 1) Thickness: 2 inch (50.8 mm)
 - 2) Thermal Resistance R13
 - 3) Thermally broken
 - 4) Meets UL94HF-1 flame requirements.
 - 5) Location and application: Full coverage of entire cabinet exterior to include walls, roof of unit, unit base, and doors.
 - b. Materials: Fiberglass insulation. If insulation other than fiberglass is used, it must also meet the Fire Hazard Classification shown below.
 - 1) Thickness: 2 inch (50.8 mm)
 - 2) Thermal Resistance R8
 - 3) Fire Hazard Classification: Maximum flame spread of 25 and smoke developed of 50, when tested in accordance with ASTM C 411.
 - 4) Location and application: Divider panels between outdoor air and return air/exhaust air streams.
2. Roof Insulation: 2 inch (50.8 mm) fiberglass located above the 1 inch (25.4 mm) foam panel.

E. Housing:

1. Access panels / doors: Unit shall be equipped with insulated, hinged doors or removable access panels to provide easy access to all major components. Doors and access panels shall be fabricated of 18 gauge galvanized G90 steel or painted galvanized steel.

F. Supply and Exhaust Fans:

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."

2. Motor Sizes: Minimum size as indicated. If size is not indicated, provide motor large enough so driven load will not require motor to operate in service factor range above 1.0.
3. Supply Air blower assemblies: Blower assembly shall consist of an electric motor and direct-drive fans. Assembly shall be mounted on heavy gauge galvanized steel rails and further mounted on 1.125 inch thick neoprene vibration isolators. Blower motors shall be capable of continuous speed modulation and controlled by a VFD.
4. Exhaust Air blower assemblies: Blower assembly shall consist of an electric motor and a direct-drive fan. Assembly shall be mounted on heavy gauge galvanized steel rails and further mounted on 1.125 inch thick neoprene vibration isolators. Blower motor shall be capable of continuous speed modulation and controlled by a VFD.
5. Connections:
6. Control panel / connections: Units shall have an electrical control center where all high and low voltage connections are made. Control center shall be constructed to permit single-point high voltage power supply connections. RTU shall be equipped with a Unit Disconnect Switch. Electric heater shall have single point power.
7. Condensate drain pan: Drain Pan shall be an integral part of the unit whenever a cooling option is included. Pan shall be formed of welded austenitic stainless steel sheet material and provided with a welded stainless steel drain connection at the front for connection to a P trap. Drain pan shall be sloped in two directions to provide positive draining and drain connector shall be sealed at penetration through cabinet wall.
8. P trap: If the unit is equipped with a condensate drain pan, contractor shall provide, or fabricate, and install an appropriate P trap, in accordance with all local and area codes and Best Practices.

G. Heating and Cooling:

1. Energy wheel: Unit energy wheel shall be sized for the full volume of outdoor and exhaust air without an energy wheel bypass damper(s). Energy wheel shall be of total enthalpy, rotary air-to-air type and shall be an element of a removable energy wheel cassette. The cassette shall consist of a galvanized steel framework (designed to produce laminar air flow through the wheel), an energy wheel as specified and a motor and drive assembly. The cassette shall incorporate a pre-tensioned urethane drive belt or a link style belt with a five-year warranty. The wheel media shall be a polymer film matrix in a stainless-steel framework and be comprised of individual segments that are removable for servicing. Non-segmented energy wheels are not acceptable. Silica gel

- desiccant shall be permanently bonded to the polymer film and is designed and constructed to permit cleaning and servicing. The energy wheel is to have a five-year warranty. Performance criteria are to be as specified in AHRI Standard 1060, complying with the Combined Efficiency data in the submittal.
2. Electric preheater shall be provided for frost control of the energy wheel. Preheater assembly shall include a thermostat and pressure sensor on the wheel assembly to initiate frost control sequence. Preheater shall comply with UL 1995 and be constructed on a galvanized steel frame.
 3. Reheat coil with factory installed modulating hot gas reheat valve.
 4. Electric Post-heater: Post-heater shall be SCR control and shall include a temperature sensor with field adjustable set point, located in the outdoor air stream. Heat output of the post-heater shall be infinitely variable. Electric post-heater shall be able to simultaneously operate with the air-source heat pump.
 5. Air-Source Heat Pump: Unit shall have an integral compressor(s) and indoor coil located within the weather-tight unit housing. Outdoor coils and appurtenant outdoor fan assemblies shall be factory installed as integral subassemblies of the unit and mounted on the exterior of the unit. Lead fan(s) will have an electronically commutated (EC) motor that will modulate to maintain a refrigerant pressure set point.] Motors shall be UL Recognized and CSA Certified. The lead refrigerant compressor shall be inverter hermetic scroll-type. Additional compressor shall be single stage hermetic scroll-type paired in tandem with lead inverter compressor. Compressors shall be equipped with liquid line filter drier, individual sight glass for heating and cooling operation, electronic expansion valves (EEV), manual reset high pressure and low pressure cutouts and all appurtenant sensors, service ports, leak detection sensors and safety devices. Compressed refrigerant system shall be fully charged with R-454B refrigerant. Each compressor shall be factory-equipped with an electric crankcase heater to boil off liquid refrigerant from the oil.
 6. Condenser Fans: Fan blades must be constructed of aluminum or a composite material and have a geometry designed and documented to reduce sound and energy when compared to a traditional rectangular blade fan. Traditional rectangular blade fans are not allowed due to increased noise generated and increase power utilized. Condenser fan motors shall be three phase, external rotor, type 56 frame, open air over and shaft up. Each condenser fan motor shall have a vented frame, rated for continuous duty and be equipped with an automatic reset thermal protector. Lead condenser fan(s) will have an electronically commutated (EC) motor that will modulate to maintain a head pressure set point.] Motors shall be UL Recognized and CSA Certified. Single condenser fan running at max RPM and design static pressure shall not

exceed an A-weighted sound power level of 75 db at free inlet/outlet test conditions.

7. Motorized dampers / Intake Air, Motorized dampers of low leakage type shall be factory installed.

H. Blowers:

1. Blower section construction, Supply Air: direct drive motor and blower shall be assembled on a 14 gauge galvanized steel platform and shall be equipped with 1.125 inch thick neoprene vibration isolation devices.
2. Blower assemblies: Shall be statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and horsepower.
3. Fan: Direct drive, airfoil plenum fan with steel wheel statically and dynamically balanced. Prop or belt-drive fan not acceptable due to low static capabilities.
4. Blades: Painted steel blades only.
5. Blower section motor source quality control: Blower performance shall be factory tested for flow rate, pressure, power, air density, rotation speed and efficiency. Ratings are to be established in accordance with AMCA 210, "Laboratory Methods of Testing Fans for Rating".

I. Motors:

1. General: Blower motors greater than 1/2 horsepower shall be "NEMA Premium" unless otherwise indicated. Compliance with EPart minimum energy-efficiency standards for single speed ODP and TE enclosures is not acceptable. Motors shall be heavy-duty, permanently lubricated type to match the fan load and furnished at the specified voltage, phase and enclosure.
2. Motors shall be 60 cycle, 3 phase 460 volts.

J. Filters, particulate air filtration is specified in Section 234100 "Particulate Air Filtration."

K. Filters:

1. Unit shall have permanent 2 inch (50.8 mm) aluminum filters located in the outdoor air intake and shall be accessible from the exterior of the unit. MERV 8 disposable pleated filters shall be provided in the supply air stream. MERV 8 and MERV 13 disposable pleated filters shall be provided in the supply final air stream and MERV 8 filters in the exhaust air stream.

L. Controls:

1. The unit shall be constructed so that it can function as a stand-alone heating and cooling system controlled by factory-supplied controllers, thermostats and sensors or it can be operated as a heating and cooling system controlled by a Building Management System (BMS). This unit shall be controlled by a factory-installed microprocessor programmable controller (DDC) that is connected to various optional sensors.
2. Unit shall incorporate a DDC controller with integral LCD screen that provides text readouts of status. DDC controller shall have a built-in keypad to permit operator to access read-out screens without the use of ancillary equipment, devices or software. DDC controllers that require the use of equipment or software that is not factory-installed in the unit are not acceptable. Alarm readouts consisting of flashing light codes are not acceptable. Owner-specified ventilating conditions can be input by means of pushbuttons.
3. Unit supply fan shall be configured for Constant Volume (ON/OFF).
4. Unit exhaust fan shall be configured for building pressure by factory.
5. Outside Air / Return Air damper control shall be
6. Economizer control shall be temperature.
7. Variable Frequency Drive (VFD): unit shall have factory installed variable frequency drive for modulation of the supply and exhaust air blower assemblies. The VFD shall be factory-programmed for unit-specific requirements and shall not require additional field programming to operate.
8. Airflow monitoring required in the supply, and exhaust airstreams.
9. Unit shall be provided with a space thermostat measuring temperature.
10. Secondary heating source shall be capable of simultaneous operation with the air-source heat pump.
- 11.

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 roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.

- C. Examine roof curbs and equipment supports for suitable conditions where units will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Installation shall be accomplished in accordance with these written specifications, project drawings, manufacturer's installation instructions as documented in manufacturer's IOM, Best Practices and all applicable building codes.

3.3 CONNECTIONS

- A. In all cases, industry Best Practices shall be incorporated. Connections are to be made subject to the installation requirements shown above.
- B. Piping installation requirements are specified in Division 22 (Plumbing). Drawings indicate general arrangement of piping, fittings and specialties.
- C. Duct installation and connection requirements are specified in Division 23 of this document.
- D. Electrical installation requirements are specified in Division 26 of this document.

3.4 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 units, allow space for service and maintenance.
- C. Connect piping to units mounted on vibration isolators with flexible connectors.

- D. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.
- E. Duct Connections:
 - 1. Comply with requirements in Section 233113 "Metal Ducts."
 - 2. Drawings indicate the general arrangement of ducts.
 - 3. Connect ducts to units with flexible duct connectors. Comply with requirements for flexible duct connectors in Section 233300 "Air Duct Accessories."

3.5 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 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 (13 mm) high.

3.6 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."

3.7 CLEANING

- A. After completing system installation; testing, adjusting, and balancing dedicated outdoor-air unit and air-distribution systems; and completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, casings, dampers, coils, and filter housings, and install new, clean filters.

3.8 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory authorized service representative to inspect field assembled components and equipment installation, to include electrical and piping connections. Report results to A / E in writing. Inspection must include a complete startup checklist to include (as a minimum) the following: Completed Start-Up Checklists as found in manufacturer's IOM.

3.9 START-UP SERVICE

- A. Engage a factory authorized service representative to perform startup service. Clean entire unit, comb coil fins as necessary, install clean filters. Measure and record electrical values for voltage and amperage. Refer to Division 23 "Testing, Adjusting and Balancing" and comply with provisions therein.

3.10 DEMONSTRATION AND TRAINING

- A. Engage a factory authorized service representative to train owner's maintenance personnel to adjust, operate and maintain the entire unit. Refer to Division 01 Section Closeout Procedures and Demonstration and Training.

END OF SECTION 237433

SECTION 23 81 26

SPLIT-SYSTEM AIR-CONDITIONERS

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Split-system air-conditioners.

1.2 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. 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. Samples for Initial Selection: For units with factory-applied color finishes.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Warranty: Sample of special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For split-system air-conditioning 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. Filters: One set(s) for each air-handling unit.
 - 2. Gaskets: One set(s) for each access door.
 - 3. Fan Belts: One set(s) for each air-handling unit fan.

1.6 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/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

1.7 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.

1.8 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: Five year(s) from date of Substantial Completion.
 - c. For Labor: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SPLIT-SYSTEM AIR-CONDITIONERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Carrier Global Corporation.
 - 2. Lennox.
 - 3. Mitsubishi Electric & Electronics USA, Inc.
 - 4. Trane.
 - 5. YORK; brand of Johnson Controls International plc, Building Solutions North America.
- B. Indoor Units (5 tons (18 kW) or Less):

- a. Wall-Mounted, Evaporator-Fan Components:
- b. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
- c. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
- d. Fan: Direct drive, centrifugal.
- e. Fan Motors:
 - 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230500 "Common Work Results for HVAC."
 - 2) Multitapped, multispeed with internal thermal protection and permanent lubrication.
 - 3) Enclosure Type: Totally enclosed, fan cooled.
 - 4) NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
 - 5) Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 - 6) Mount unit-mounted disconnect switches on exterior of unit.
- f. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- g. Condensate Drain Pans:
 - 1) 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.
 - a) Length: Extend drain pan downstream from leaving face.
 - b) Depth: A minimum of 1 inch (25 mm) deep.
 - 2) Single-wall, stainless-steel sheet.
 - 3) Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
 - 4) Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
 - 5) Minimum Connection Size: NPS 1 (DN 25).
 - 6) Pan-Top Surface Coating: Asphaltic waterproofing compound.
- h. Air Filtration Section:
 - 1) General Requirements for Air Filtration Section:
 - a) Comply with NFPA 90A.

- b) Minimum MERV according to ASHRAE 52.2.
 - c) Filters shall be accessible for routine maintenance and cleaning by lifting the unit's front intake panel; no tools shall be required.
 - 2) Primary Pre-Filter:
 - a) Type: Washable, long-life, polymer mesh pre-filter.
 - b) Function: Removes lint, dust, and large airborne particulates to protect the indoor coil.
 - c) Frame: Lightweight, removable, and cleanable plastic.
 - d) Maintenance: Filter shall be removable and cleanable by washing with water, with a typical service life of over 10 years.
 - 3) C. Secondary Deodorizing/Allergen Filter:
 - a) Type: Manufacturer's standard advanced filter (e.g., Nano-Platinum or Catechin-based).
 - b) Function: Provides odor absorption and traps fine allergens, pollen, and other contaminants.
 - c) Maintenance: Shall be replaceable as recommended by the manufacturer.
- i. Outdoor Units (5 tons (18 kW) or Less:
- 2. Air-Cooled, Compressor-Condenser Components:
 - a. 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.
 - b. 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.
- 1) Compressor Type: Scroll.

- 2) Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
- 3) Refrigerant: R454B, R32.
- 4) Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.
- c. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
- d. Fan: Aluminum-propeller type, directly connected to motor.
- e. Motor: Permanently lubricated, with integral thermal-overload protection.
- f. Low Ambient Kit: Permits operation down to 45 deg F (7 deg C).
- g. Mounting Base: Polyethylene.
- h. EXECUTION

2.2 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 cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Install ground-mounted, compressor-condenser components on polyethylene mounting base.
 - 3. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 4. 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.

2.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
 - 1. Water Coil Connections: Comply with requirements specified in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Connect hydronic piping to supply and return coil connections with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
 - 2. Remote, Water-Cooled Condenser Connections: Comply with requirements specified in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties." Connect hydronic piping to supply and return connections with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
- B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

2.4 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. 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.

2.5 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.

2.6 DEMONSTRATION

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

END OF SECTION 238126

SECTION 23 81 29

VARIABLE-REFRIGERANT-FLOW HVAC SYSTEMS

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: VRF HVAC systems.
1. Indoor, concealed, ceiling-mounted units for ducting.
 2. Indoor, concealed, floor-mounted units for ducting.
 3. Indoor, exposed, floor-mounted units.
 4. Indoor, exposed, wall-mounted units.
 5. Indoor, recessed, ceiling-mounted units.
 6. Indoor, suspended, ceiling-mounted units.
 7. Indoor, hydronic heat exchangers.
 8. Indoor, dedicated outdoor air ventilation units.
 9. Indoor, energy recovery ventilator.
 10. Indoor, hydronic heat-pump units.
 11. Indoor, hydronic heat recovery units.
 12. Outdoor, air-source heat-pump units.
 13. Outdoor, air-source heat recovery units.
 14. Heat recovery control units (HRCUs).
 15. System controls.
 16. System refrigerant and oil.
 17. System condensate drain piping.
 18. System hydronic piping.
 19. System refrigerant piping.
 20. Metal hangers and supports.
 21. Metal framing systems.
 22. Fastener systems.
 23. Pipe stands.
 24. Outdoor equipment stands.

- 25. Miscellaneous support materials.
- 26. Piping and tubing insulation.
- 27. System control cable.

1.2 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.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

- A. Product Data: For VRF HVAC system components.
 - 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. Samples for Initial Selection: For fully and partially exposed indoor units with factory finishes viewable by occupants.
 - 1. Include a Sample for each unique finish with unit identification, detailed description of application, and cross-referenced floor plans showing locations.
- D. Delegated Design Submittals:
 - 1. Include design calculations for selecting vibration isolators and seismic restraints 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.

1.5 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.
 - f. Coordinate "Qualification Data" Paragraph below with qualification requirements in Section 014000 "Quality Requirements" and as may be supplemented in "Quality Assurance" Article.
- 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. Seismic Qualification Data: Certificates, for equipment, 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.
 - D. Product Certificates: For VRF HVAC system components.
 - E. Product Test Reports: Where tests are required, for each product, for tests performed by manufacturer and witnessed by a qualified testing agency or a qualified testing agency.
 - F. Source quality-control reports.
 - G. Field quality-control reports.
 - H. Sample Warranties: For manufacturer's warranties.
- 1.6 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.

1.7 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. 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.
 2. Indoor Units: One for each unique size and type installed.
 3. Controllers for Indoor Units: One for each unique controller type installed.

1.8 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 10 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 100 miles of Project.
 3. Demonstrated past experience with products being installed for period within five 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 five consecutive years before time of bid.
 - b. Demonstrated past experience on five projects of similar complexity, scope, and value.
- D. Mockups: Build mockups to set quality standards for materials and execution.
 1. Build mockups to show a finished installation for each of the following applications:
 - a. For each different indoor unit type with exposed surfaces viewable by occupants.
 - b. Mockups shall be operational.
 2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
- E. ISO Compliance: System equipment and components furnished by VRF HVAC system manufacturer shall be manufactured in an ISO 9001 and ISO 14001 facility.

1.9 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.

1.10 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.
 - d. Verify available warranties and warranty periods for units and components.
 - 2. Warranty Period:
 - a. For Compressor: Seven year(s) from date of Substantial Completion.
 - b. For Parts, Including Controls: Seven year(s) from date of Substantial Completion.
 - c. For Labor: Seven year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 VRF HVAC SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Daikin Applied.
 2. LG Electronics USA, Inc.; LG Electronics Inc.
 3. Mitsubishi Electric Cooling and Heating.
 4. Trane Inc.
- 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. Refrigerant isolation valves.
 4. Specialty refrigerant pipe fittings.

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, outdoor unit(s), piping, controls, and electrical power to make complete operating system(s) complying with requirements indicated.
1. Two-pipe system design.
 2. System(s) operation, air-conditioning heat pump 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 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 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 (450-mm) 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.
 2. Each branch circuit shall accommodate addition of minimum two indoor unit(s) with unit capacity equal to average indoor unit connected to the branch circuit.
 3. Each branch circuit shall accommodate deletion of two indoor unit(s) with unit capacity equal to average indoor unit connected to the branch circuit.
- E. Isolation of Equipment: Provide isolation valves to isolate each 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 50 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/SEI 7.
 - 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. Seismic Performance: VRF HVAC system(s) shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
 - 2. Component Importance Factor: 1.5.
- K. Sound Performance: Sound levels generated by operating HVAC equipment shall be within requirements indicated.
 - 1. Indoor: Within design guidelines of "2015 ASHRAE HANDBOOK- HVAC Applications."
 - 2. Outdoor: Within ordinance of governing authorities.
- L. Thermal Movements: Allow for controlled thermal movements from ambient, surface, and system temperature changes.
- M. 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 8.
 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. Unit Accessories:
1. Outdoor Air Ventilation Kit: Connection, motorized damper, and control sized to allow sequence of operation indicated on Drawings.
 2. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
- H. Unit Controls:
1. Enclosure: Metal, suitable for indoor locations.
 2. Factory-Installed Controller: Configurable digital control.
 3. Factory-Installed Sensors:
 - a. Unit inlet air temperature.
 - b. Coil entering refrigerant temperature.

- c. Coil leaving refrigerant temperature.
 - d. Refrigerant leakage detection sensor.
- 4. Field-Customizable I/O Capability:
 - a. Analog Inputs: Three for use in customizable control strategies.
 - b. Digital Inputs: Three for use in customizable control strategies.
 - c. Digital Outputs: Three for use in customizable control strategies.
- 5. 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.
 - k. Refrigerant leakage detection. Valve shutdown and notification.
- 6. Communication: Network communication with other indoor and outdoor units.
- 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.
- I. 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.
 - a. INDOOR, RECESSED, CEILING-MOUNTED UNITS
- J. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to ductwork, piping, power, and controls field connections.
- K. 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.

L. 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.

M. 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.

N. 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.
- O. Filter Assembly:
1. Access: Bottom, to accommodate filter replacement without the need for tools.
 2. Efficiency: ASHRAE 52.2, MERV 8.
 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.
- P. 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.
- Q. Return-Air Grille Assembly: Manufacturer's standard grille mounted in bottom of unit cabinet.
- R. Outdoor Air Ventilation Connection: Sheet metal knockout for optional connection to outdoor air ventilation duct.
- S. Unit Accessories:
1. Outdoor Air Ventilation Kit: Connection, motorized damper, and control to satisfy unit control sequence of operation indicated on Drawings.

2. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
3. Condensate pump.

T. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors: Unit inlet air temperature, Coil entering refrigerant temperature, Coil leaving refrigerant temperature, .
4. Field-Customizable I/O Capability:
 - a. Analog Inputs: Three for use in customizable control strategies.
 - b. Digital Inputs: Three for use in customizable control strategies.
 - c. Digital Outputs: Three for use in customizable control strategies.
5. Features and Functions: Self-diagnostics, time delay, auto-restart, external static pressure control , auto operation mode , manual operation mode , filter service notification , power consumption display , drain assembly high water level safety shutdown and notification , run test switch and refrigerant leakage detection sensor, valve shutdown and notification.
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.

U. 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.

2.5 INDOOR, SUSPENDED, CEILING-MOUNTED 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.
- 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: Gravity.
 - a. If a floor drain is not available at unit, provide unit with field-installed condensate pump accessory.
 - 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: Front, to accommodate filter replacement without the need for tools.
 2. Efficiency: Merv 8.
 3. Washable Media: Manufacturer's standard filter with antimicrobial treatment.
- G. Discharge-Air Grille Assembly: Mounted in front of unit cabinet.
1. Discharge Pattern: One-way throw.
 2. Discharge Pattern Adjustment: Field-adjustable limits for range of pattern.
 3. Motorized Vanes: Modulating up and down flow pattern for uniform room air distribution.
- H. Return-Air Grille Assembly: Manufacturer's standard.
- I. Outdoor Air Ventilation Connection: Sheet metal knockout for optional connection to outdoor air ventilation duct.
- J. Unit Accessories:
1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
 2. Condensate Pump: Integral reservoir and control with electrical power connection through unit power.
- K. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
 2. Factory-Installed Controller: Configurable digital control.
 3. Factory-Installed Sensors: Unit inlet air temperature Coil entering refrigerant temperature Coil leaving refrigerant temperature Insert sensor.
 4. Field-Customizable I/O Capability:
 - a. Analog Inputs: Three for use in customizable control strategies.
 - b. Digital Inputs: Three for use in customizable control strategies.
 - c. Digital Outputs: Three for use in customizable control strategies.
 5. Features and Functions: Self-diagnostics, time delay, auto-restart, external static pressure control , auto operation mode , manual operation mode , filter service notification , power consumption display , drain assembly high water level safety shutdown and notification , run test switch,.
 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.
- L. 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.
 - a. OUTDOOR, AIR-SOURCE HEAT-PUMP UNITS
- M. 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 either all heating or all cooling demands, but not 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.

N. Cabinet:

1. Galvanized steel and coated with a corrosion-resistant finish.
 - a. Coating with documented salt spray test performance of 1000 hours according 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.

O. 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.
 - h. Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
3. Vibration Control: Integral isolation to dampen vibration transmission.
4. Oil management system to ensure safe and proper lubrication over entire operating range.
5. Crankcase heaters with integral control to maintain safe operating temperature.
6. Fusible plug.

P. 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. Aluminum Microchannel Coils:
 - a. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
 - b. Single- or multiple-pass arrangement.
 - c. Construct fins, tubes, and header manifolds of aluminum alloy.
 - 3. Coating: Corrosion resistant.
 - 4. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
- Q. 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.
- R. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.
- S. 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.
 - g. "Features and Functions" Subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.
 - 4. Features and Functions: Self-diagnostics, time delay, auto-restart, fuse protection, auto operation mode , manual operation mode , night setback control , power consumption display , run test switch equalize run time between multiple same components.
 - 5. Communication: Network communication with indoor units and other outdoor unit(s).
 - 6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 - 7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- T. 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.
- U. 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 hours according ASTM B117.
- V. 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.

2.6 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 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.
 - h. Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
 3. Vibration Control: Integral isolation to dampen vibration transmission.
 4. Oil management system to ensure safe and proper lubrication over entire operating range.
 5. Crankcase heaters with integral control to maintain safe operating temperature.

6. 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. Aluminum Microchannel Coils:
 - a. Series of flat tubes containing a series of multiple, parallel-flow microchannels layered between refrigerant header manifolds.
 - b. Single- or multiple-pass arrangement.
 - c. Construct fins, tubes, and header manifolds of aluminum alloy.
 3. Coating: Corrosion resistant.
 4. 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.
 - g. "Features and Functions" Subparagraph below indicates requirements that may not be available on some products from some manufacturers. Consult manufacturers for availability.
 4. Features and Functions: Self-diagnostics, time delay, auto-restart, fuse protection, auto operation mode , manual operation mode , night setback control , power consumption display , run test switch equalize run time between multiple same components .
 5. Communication: Network communication with indoor units and other outdoor unit(s).
 6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- 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 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. Spares: Each heat recovery control unit shall include at least one branch circuit port(s) for future use.
 4. 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.

5. 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. Factory-Installed Sensors: refrigerant leakage detection sensor.
4. Features and Functions: Self-diagnostics, fuse protection.
5. Communication: Network communication with indoor units and outdoor unit(s).
6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. 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 TIA-485A or manufacturer-selected control network.
2. Network Communication Protocol: Manufacturer proprietary or open 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 devices shall be connected to local uninterruptible power supply unit(s) to provide at least 5 minutes of battery backup operation after a power loss.
 - c. Integration shall include control, monitoring, scheduling, and change of value notifications.
 - d. Operator Interface:
 - e. Operators shall interface with system and unit controls through the following:
 - 1) Operator interfaces integral to controllers.
 - 2) Owner-furnished PC connected to central controller(s).
 - 3) Web interface through web browser software.
 - 4) Integration with Building Automation System.
 - f. 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) On/off control.
 - 2) 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 or Spanish.
10. Supports Imperial and Metric Temperature Units: Fahrenheit and Celsius.
11. Displays service notifications and error codes.
12. Monitors and displays up to 3000 item error history and 10000 item 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.

C. Central Controllers:

1. Centralized control for all indoor and outdoor units from a single central controller location.
 - a. Include multiple interconnected controllers as required.
2. 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.
3. Schedule operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
 - a. Sets schedule for daily, weekly, and annual events.
 - b. Schedule options available through central controller shall at least include the schedule options of controllers for indoor units.
4. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
5. Optimized start feature to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.

6. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
7. Service diagnostics tool.
8. Able to disable and enable operation of individual controllers for indoor units.
9. Information displayed on individual controllers shall also be available for display through central controller.
10. Information displayed for outdoor units, including refrigerant high and low pressures percent capacity.
11. Multiple RJ-45 ports for direct connection to a local PC and an Ethernet network switch.
12. Operator interface through a backlit, high-resolution color display touch panel and web accessible through standard web browser software.

D. Wired Controllers for Indoor Units:

1. Single controller capable of controlling multiple indoor units as group.
2. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
3. Multiple Language: English or Spanish.
4. Temperature Units: Fahrenheit and Celsius.
5. On/Off: Turns indoor unit on or off.
6. Hold: Hold operation settings until hold is released.
7. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
8. Temperature Display: 1-degree increments.
9. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments between -15 to 120.
10. Relative Humidity Display: 1 percent increments.
11. Relative Humidity Set-Point: Adjustable in 1 percent increments between 10% to 90%.
12. Fan Speed Setting: Select between available options furnished with the unit.
13. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
14. Seven-day programmable operating schedule with up to five events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
15. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
16. Occupancy detection.
17. Service Notification Display: "Filter".
18. Service Run Tests: Limit use by service personnel to troubleshoot operation.
19. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
20. User and Service Passwords: Capable of preventing adjustments by unauthorized users.

21. Setting stored in nonvolatile memory to ensure that settings are not lost if power is lost. Battery backup for date and time only.
22. Low-voltage power required for controller shall be powered through non-polar connections to indoor unit.

E. Wireless Controllers for Indoor Units:

1. Wireless Communication:
 - a. Controller communicates to remote-mounted receiver that is wired to indoor unit(s).
 - 1) Include receivers with wireless controllers as required to complete installation.
 - 2) Low-voltage power required for receivers shall be powered through non-polar connections to indoor unit.
 - b. One wireless controller shall be capable of communicating with one or multiple receivers to control one or multiple indoor units as a group.
2. Controller Battery Life: Three years.
3. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
4. Multiple Language: English or Spanish.
5. Temperature Units: Fahrenheit and Celsius.
6. On/Off: Turns indoor unit on or off.
7. Hold: Hold operation settings until hold is released.
8. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
9. Temperature Display: 1-degree increments.
10. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments between -15 to 120.
11. Relative Humidity Display: 1 percent increments.
12. Relative Humidity Set-Point: Adjustable in 1 percent increments between 10% to 90%.
13. Fan Speed Setting: Select between available options furnished with the unit.
14. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
15. Seven-day programmable operating schedule with up to five events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
16. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
17. Occupancy detection.
18. Service Notification Display: "Filter".
19. Service Run Tests: Limit use by service personnel to troubleshoot operation.
20. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
21. User and Service Passwords: Capable of preventing adjustments by unauthorized users.

22. Setting stored in non-volatile memory to ensure that settings are not lost if power is lost. Battery for date and time only.

2.9 SYSTEM REFRIGERANT AND OIL

A. Refrigerant:

1. As required by VRF HVAC system manufacturer for system to comply with performance requirements indicated.
2. ASHRAE 15: Safety Standard for Refrigeration Systems.
3. ASHRAE 34: Designation and Safety Classification of Refrigerants.
4. 32 or R454B.

B. Oil:

1. As required by VRF HVAC system manufacturer and to comply with performance requirements indicated.

2.10 SYSTEM CONDENSATE DRAIN PIPING

A. If more than one material is listed, material selection is Contractor's option.

B. Copper Tubing:

1. Drawn-Temper Tubing: According to ASTM B88, Type L (ASTM B88M, Type B) or Type DWV according to ASTM B306.
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.

C. CPVC plastic pipe according to ASTM F441/F441M, Schedule 40, with socket-type pipe fittings according to ASTM F438 and solvent cement according to ASTM F493.

D. PVC plastic pipe according to ASTM D1785, Schedule 40, with socket-type pipe fittings according to ASTM D2466 and solvent cement according to ASTM D2564, primer according to ASTM F656.

2.11 SYSTEM REFRIGERANT PIPING

A. Comply with requirements in Section 232300 "Refrigerant Piping" for system piping requirements.

B. Refrigerant Piping:

1. Copper Tube: ASTM B280, Type ACR.
2. Wrought-Copper Fittings: ASME B16.22.
3. Brazing Filler Metals: AWS A5.8/A5.8M.

C. Refrigerant Tubing Kits:

1. Furnished by VRF HVAC system manufacturer.
2. Factory-rolled and -bundled, soft-copper tubing with tubing termination fittings at each end.
3. Standard one-piece length for connecting to indoor units.
4. Pre-insulated with flexible elastomeric insulation of thickness to comply with governing energy code and sufficient to eliminate condensation.
5. Factory Charge: Dehydrated air or nitrogen.

D. Divided-Flow Specialty Fittings: Where required by VRF HVAC system manufacturer for proper system operation, VRF HVAC system manufacturer shall furnish specialty fittings with identification and instructions for proper installation by Installer.

E. 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 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.

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.

2.13 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB Electrification Installations Products.
 - b. Cooper B-line; brand of Eaton, Electrical Sector.
 - c. Flex-Strut Inc.
 - d. Haydon Corp.
 - e. MIRO 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 factory-fabricated components for field assembly.
4. Channels: Continuous slotted stainless steel, Type 304 channel with inturned lips.
5. Channel Width: Selected for applicable load criteria.
6. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
7. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel for use indoors and of stainless steel for use outdoors.
8. Metallic Coating for Use Indoors: Electroplated zinc.
9. Plastic Coating for Use Outdoors: PVC.

2.14 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.

2.15 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:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. MIRO Industries Inc.
 - b. PHP Systems/Design.
 - c. RectorSeal HVAC; a CSW Industrials Company.
 - 2. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
 - 3. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
 - a. Hardware: Galvanized steel or polycarbonate.
 - 4. Accessories: Protection pads.
- C. Low-Profile, Single-Base, Single-Pipe Stand:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. MIRO Industries Inc.
 - b. PHP Systems/Design.
 - c. OMG Roofing Products
 - 2. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
 - 3. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
 - a. Vertical Members: Two, stainless-steel, continuous-thread 1/2-inch (12-mm) rods.
 - 4. Horizontal Member: Adjustable horizontal, stainless steel pipe support channels.
 - 5. Pipe Supports: Roller or Strut clamps or Clevis hanger.
 - 6. Hardware: Stainless steel.
 - 7. Accessories: Protection pads.
 - 8. Height: 12 inches above ground.
- D. High-Profile, Single-Base, Single-Pipe Stand:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. MIRO Industries Inc.
 - b. PHP Systems/Design.
 - c. OMG Roofing Products

2. Description: Single base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
3. Base: Single vulcanized rubber or molded polypropylene.
 - a. Vertical Members: Two, stainless steel, continuous-thread 1/2-inch (12-mm) rods.
4. Horizontal Member: One, adjustable height, stainless steel pipe support slotted channel or plate.
5. Pipe Supports: Roller or Clevis hanger.
6. Hardware: Stainless steel.
7. Accessories: Protection pads, 1/2-inch (12-mm) continuous-thread stainless steel rod.
8. Height: 36 inches (900 mm) above ground.

E. High-Profile, Multiple-Pipe Stand:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. MIRO Industries Inc.
 - b. PHP Systems/Design.
 - c. OMG Roofing Products
2. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
3. Bases: Two or more; molded polypropylene.
 - a. Vertical Members: Two or more, stainless steel channels.
4. Horizontal Members: One or more, adjustable height, stainless steel pipe support.
5. Pipe Supports: Roller or Strut clamps or Clevis hanger.
6. Hardware: Stainless steel.
7. Accessories: Protection pads, 1/2-inch (12-mm) continuous-thread rod.
8. Height: 36 inches (900 mm) above roof.

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.

2.16 OUTDOOR EQUIPMENT STANDS

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

1. MIRO Industries Inc.
2. RectorSeal HVAC; a CSW Industrials Company.

3. OMG Roofing Products

- B. Description: Individual foot supports with elevated adjustable channel cross bars and clamps/fasteners/bolts for ground or roof-supported outdoor equipment components, without roof membrane penetration, in a prefabricated system that can be modularly assembled on-site.
- C. Foot Material: Rubber or polypropylene.
- D. Rails Material: Hot-dip galvanized carbon steel.
- E. Wind/Sliding Load Resistance: Up to 100 mph (44 m/s) minimum.

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 (34.5-MPa), 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 insulation requirements.
- B. Condensate Drain Piping and Tubing Insulation and Jacket Requirements:
 - 1. Flexible Elastomeric Insulation:
 - a. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C534, Type I for tubular materials.
 - b. Indoors: 1/2 inch (12.5 mm) thick.
 - c. Outdoors: 1 inch (25 mm) thick.
 - 2. Field-Applied Jacket:

- a. Concealed: None required.
 - b. Indoors, Exposed to View: PVC, 20 mils (0.5 mm) thick.
 - c. Outdoors, Exposed to View: Aluminum, smooth, 0.020 inch (0.51 mm) thick.
 - C. Refrigerant Tubing Insulation and Jacket Requirements:
 - 1. Flexible Elastomeric Insulation:
 - a. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C534, Type I for tubular materials.
 - b. Indoors: 1 inch (25 mm) thick.
 - c. Outdoors: 1 inch (25 mm) thick.
 - 2. Field-Applied Jacket:
 - a. Concealed: None required.
 - b. Indoors, Exposed to View: PVC, 20 mils (0.5 mm) thick.
 - c. Outdoors, Exposed to View: Aluminum, smooth, 0.020 inch (0.51 mm) thick.
 - D. Flexible Elastomeric Insulation Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - E. PVC Jacket Adhesive: Compatible with PVC jacket.
 - F. Metal Jacket Flashing Sealants:
 - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 2. Fire- and water-resistant, flexible, elastomeric sealant.
 - 3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 - 4. Color: Aluminum.
- 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 (1520 mm) 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, one pair, 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, one pair, 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: Shielded twisted pairs (FTP).
4. Cable Rating: By application.
5. Jacket: Yellow thermoplastic.

E. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" for 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.

E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.

F. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a 3000-hour salt-spray test according to ASTM B117.

1. Standards:
 - a. ASTM B117 for salt spray.
 - b. ASTM D2794 for minimum impact resistance of 100 in-lb (11.3 N-m).
 - c. ASTM B3359 for cross-hatch adhesion of 5B.
2. Application: Spray.
3. Thickness: 1 mil (0.025 mm).
4. Gloss: Minimum gloss of 60 on a 60-degree meter.

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 or system Installer under supervision of manufacturer's service representative.
- C. Equipment Restraint Installation: Install equipment with seismic-restraint device. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

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 (10 mm).
- 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 (13 mm).
- H. For floor- and wall-mounted units that are exposed, conceal piping and tubing, controls, and electrical power serving units within walls.
- I. Install floor-mounted units on support structure indicated on Drawings.

- J. Install floor-mounted units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
- K. Attachment: Install hardware for proper attachment to supported equipment.
- L. Grouting: Place grout under equipment supports and make bearing surface smooth.

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.
- C. Pad-Mounted Installations: Install outdoor units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Attachment: Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 2. Grouting: Place grout under equipment supports and make bearing surface smooth.
- D. Roof-Mounted Installations: Install outdoor units on equipment supports specified in Section 077200 "Roof Accessories." Anchor units to supports with removable, stainless steel fasteners.

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 230500 "Common Work Results for HVAC."
- L. Install escutcheons for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230500 "Common Work Results for HVAC."

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 HYDRONIC PIPING

- A. Comply with requirements for hydronic pipe and tubing specified in Section 232113 "Hydronic Piping."
- B. Comply with requirements for hydronic specialties specified in Section 232116 "Hydronic Piping Specialties."
- C. Comply with requirements for ball valves specified in Section 230523 "General-Duty Valves for HVAC Piping."
- D. Comply with requirements for butterfly valves specified in Section 230523 "General-Duty Valves for HVAC Piping."
- E. Comply with requirements for check valves specified in Section 230523 "General-Duty Valves for HVAC Piping."
- F. Install continuous-thread hanger rods and spring hangers of size required to support equipment weight.
 1. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC." Fabricate brackets or supports as required.
 2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- G. Where installing piping and tubing adjacent to equipment, allow space for service and maintenance.

3.8 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 ft. (1.5 m). Minimum rod size, 1/4 inch (6.4 mm).
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.

3.9 INSTALLATION OF METAL HANGERS AND SUPPORTS

- A. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- B. 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.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- D. Comply with MFMA-103 for metal framing system selections and applications that are not specified.
- 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.
 3. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
- 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. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- H. 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.
- I. Install lateral bracing with pipe hangers and supports to prevent swaying.
- J. 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.
- K. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- L. 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.
- M. 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 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
- N. 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 (DN 15 to DN 750).
 2. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), 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.
- O. 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 (DN 20): Maximum span, 5 ft. (1.5 m); minimum rod size, 1/4 inch (6.4 mm).
 2. NPS 1 (DN 25): Maximum span, 6 ft. (1.8 m); minimum rod size, 1/4 inch (6.4 mm).
 3. NPS 1-1/4 (DN 32): Maximum span, 7 ft. (2.1 m); minimum rod size, 3/8 inch (10 mm).
 4. NPS 1-1/2 (DN 40): Maximum span, 8 ft. (2.4 m); minimum rod size, 3/8 inch (10 mm).
 5. NPS 2 (DN 50): Maximum span, 8 ft. (2.4 m); minimum rod size, 3/8 inch (10 mm).
 6. NPS 2-1/2 (DN 65): Maximum span, 9 ft. (2.7 m); minimum rod size, 3/8 inch (10 mm).
 7. NPS 3 (DN 80) and Larger: Maximum span, 10 ft. (3 m); minimum rod size, 3/8 inch (10 mm).
- P. Plastic Pipe Hanger and Support Spacing:
1. Space hangers and supports according to pipe manufacturer's written instructions for service conditions.
 2. Maximum spacing, 5 ft. (1.5 m); minimum rod size, 1/4 inch (6.4 mm).
- Q. 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.
- R. Support vertical runs at roof, at each floor, and at midpoint intervals between floors, not to exceed 5 ft. (1.5 m).

- S. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified.
- T. Use hangers, supports, and attachments with galvanized coatings unless otherwise indicated.
- U. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- V. Trim excess length of continuous-thread hanger and support rods to 1 inch (25 mm).
- W. Hanger-Rod Attachments: Install the following types:
 - 1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
 - 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) 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 (49 to 232 deg C) piping installations.
- X. 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-joist 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 (340 kg).
 - b. Medium (MSS Type 32): 1500 lb (680 kg).
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.

3.10 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 (25-mm) 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 (50-mm) 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 (300 mm) o.c. and at end joints.

3.11 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 nonmetal ducts specified in Section 233116 "Nonmetal Ducts."
- D. Comply with requirements for air duct accessories specified in Section 233300 "Air Duct Accessories."
- E. Comply with requirements for flexible ducts specified in Section 233346 "Flexible Ducts."
- F. Comply with requirements for air diffusers specified in Section 233713.13 "Air Diffusers."
- G. Comply with requirements for registers and grilles specified in Section 233713.23 "Registers and Grilles."

3.12 ELECTRICAL CONNECTIONS

- 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 (13 mm) high.
 - 2. Locate nameplate or label where easily visible.
- G. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems" for raceway selection and installation requirements for conduits as supplemented or revised in this Section.
- H. Comply with requirements in Section 260533.16 "Boxes and Covers for Electrical Systems" for box selection and installation requirements for boxes as supplemented or revised in this Section.
- I. Comply with requirements in Section 260533.23 "Surface Raceways for Electrical Systems" for wireways selection and installation requirements for wireways as supplemented or revised in this Section.
 - 1. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.
 - 2. Outlet boxes for cables shall be no smaller than 4 inches (102 mm) square by 1-1/2 inches (38 mm) deep with extension ring sized to bring edge of ring to within 1/8 inch (3.1 mm) of the finished wall surface.
 - 3. Flexible metal conduit shall not be used.
- J. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.
- K. Install manufactured conduit sweeps and long-radius elbows if possible.

- L. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.13 SOFTWARE

A. Cybersecurity:

1. Software:

- a. Coordinate security requirements with IT department or CIO.
- 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 IT department or CIO.
- b. Enable highest level of wireless encryption that is compatible with Owner's ICT network.
- c. Disable dual network connections.

3.14 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 accessible ceiling spaces where open cable installation method may be used.
- c. 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 (760 mm) and not more than 6 inches (150 mm) 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 (13 mm) 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 (200 mm) above ceilings by cable supports not more than 30 inches (760 mm) 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.

3.15 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.

3.16 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."

3.17 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.

3.18 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 an employee or 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.
 - a. Additional factory-authorized representatives may assist with completion of certain activities only if supervised by manufacturer's employee. A factory-authorized representative shall not provide assistance without manufacturer's employee supervision.
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 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. Inspection reports for indoor, dedicated outdoor air ventilation 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) Fan external static pressure setting.
 - 19) Filter type and condition acceptable.
 - 20) Noise level within an acceptable range.
 - 21) Refrigerant piping properly connected and insulated.
 - 22) Condensate drain piping properly connected and insulated.
 - 23) Automatic dampers properly installed and operating.
 - 24) Ductwork properly connected.
 - 25) If applicable, external interlocks properly connected.
 - 26) Remarks.

- g. Inspection reports for energy recovery ventilators 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 readings.
 - 16) Condensate removal acceptable.
 - 17) Fan settings and readings within an acceptable range.
 - 18) Fan external static pressure setting.
 - 19) Filter type and condition acceptable.
 - 20) Noise level within an acceptable range.
 - 21) Automatic dampers properly installed and operating.
 - 22) Ductwork properly connected.
 - 23) If applicable, external interlocks properly connected.
 - 24) Remarks.
- h. Inspection reports for hydronic 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) Condensate removal acceptable.
 - 16) Noise level within an acceptable range.
 - 17) Refrigerant piping properly connected and insulated.
 - 18) Hydronic piping properly connected and insulated.
 - 19) Proof of water flow checked for proper operation.
 - 20) Condensate drain piping properly connected and insulated.

- 21) If applicable, external interlocks properly connected.
 - 22) Remarks.
 - i. Installer shall provide manufacturer with the requested documentation and technical support during inspection.
 - j. Installer shall correct observed deficiencies found by the inspection.
 - k. 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.
 - l. 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.
 - m. 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 1.2 times VRF HVAC system operating pressure, but not less than 600 psig (4137 kPa), 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.

3.19 STARTUP SERVICE

- A. Engage a VRF HVAC system manufacturer's service representative to perform system(s) startup service.
 1. Service representative shall be an employee or 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.

3.20 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.

3.21 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.

3.22 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of system Installer who are 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.

3.23 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.

3.24 DEMONSTRATION

- A. Engage a VRF HVAC system manufacturer's employed training instructor or 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 or Owner before scheduling training.
 - 3. Instructor(s) primary sole 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 Architect, Commissioning Agent or Owner written acceptance that training is complete and requirements indicated have been satisfied.

END OF SECTION 238129

SECTION 23 81 46.15

AIR -TO- WATER HEAT PUMPS

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

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. Packaged, air-cooled, electric-motor-driven, modular scroll water heat pumps.

1.3 ACTION SUBMITTALS

- A. Submittal Compliance
 - 1. Comparison Schedule:
 - a. Submit a schedule to indicate performance of equipment scheduled on Drawings directly compared to performance of submitted equipment.
 - b. In instances when more than 5 submittals are provided with a single submission, the time period for review will be extended and the release of submittals will be coordinated based on contractors' priority for release of equipment.
 - c. Clearly identify each line in schedule to indicate "Scheduled" where indicating performance scheduled on Drawings and "Submitted" where indicating performance of submitted equipment.
 - d. Organize schedule to first indicate performance scheduled on Drawings on one line followed by line directly below that indicates performance of submitted equipment.
 - e. Comparison schedule shall follow arrangement and organization of scheduled information indicated on Drawings.

- f. Submitted equipment shall have a value for each scheduled value indicated.
- 2. Allow 3 weeks for large submittals such as AHUs, cooling towers, chillers, and controls.
- 3. Contractor to submit a specification compliance document. This is to note acceptance or deviation from all sections in the specifications.
- 4. All submittals to be digital and searchable. Scanned submittals are not acceptable.
- 5. General contractor comments must be actioned on submittal before submitting to the engineer for review.
- B. Product Data: For each type of product.
 - 1. Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories for each model.
- C. Sustainable Design Submittals:
 - 1. Product data showing compliance with ASHRAE 62.1.
 - 2. Product Data: For energy performance.
- D. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, supports, components, and location and size of each field connection.
 - 1. Include diagrams for power, signal, and control wiring.
 - 2. Where modules are provided pre-wired to a single point power connection, provide full load amperage, minimum circuit amperage, Short-Circuit Current Rating, and maximum overcurrent protection size for single point power.
- E. Certificates: For certification required in "Quality Assurance" Article.
- F. Startup service reports.
- G. Operation and maintenance data.
- H. Warranty.

1.4 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. Structural members to which heat pumps are attached.
 2. Method of attaching supports to building structure.
 3. Size and location of module access clearance.
 4. Pre-fabricated skid construction & size, if applicable.
- B. Field quality-control reports.
- C. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For water-to-air heat pumps to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. ASHRAE Compliance:
1. ASHRAE 15.
 2. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- B. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- C. Comply with NFPA 70.
- D. Heat pumps shall be manufactured in an ISO 9001 certified facility.
- E. Each module shall be factory performance tested on a third party certified test stand to ensure proper operation in heating and cooling design conditions, full load efficiency and full load capacity. Test reports shall be made available to owner and engineer upon request. AHRI certification does not preclude heat pump from performance test requirement.
1. Functional Test
 - a. Pre-charge unit with nitrogen and test for leakage
 - b. Establish a vacuum to remove all gas and to eliminate moisture inside the refrigerant circuit
 - c. Charge the unit with refrigerant
 - d. Connect the evaporator and condensers inlet and outlet water connections to the testing room plant
 - e. Set the water flow to the design flow rate

- f. Connect power to the unit and carry out test of voltage and frequency on the electrical panel
 - g. Program the microprocessor control with basic working parameters
 - h. Set up the valves and trim the refrigerant charge
 - i. Start up each compressor and test electrical data
 - j. Set up all the pressure switches
 - k. Calibrate the various temperature and pressure probes on the circuit
 - 2. Performance Test
 - a. Test the following alarms on the microprocessor through run test
 - 1) High pressure alarm
 - 2) Low pressure alarm
 - 3) Compressors alarm
 - 4) Evaporator freeze alarm
 - b. Test probe failures
 - c. Run the heat pump in the production climatic test chamber at full load conditions at design conditions (each circuit):
 - d. Record the performance data on the test report sheet and provide a copy to engineer and owner.
 - e. Each compressor circuit will be run separately.
 - F. Sound Compliance: heat pump sound power levels shall be rated according to ISO 9614-2 and sound pressure levels rated to ISO 3744 standards. If alterations are made to a standard heat pump to comply with the sound requirements, the manufacturer must provide a sound performance test in a certified facility.
 - G. Comply with safety requirements in UL 484 for assembly of free-delivery, air-source heat pumps.
 - H. Comply with safety requirements in UL 1995 for hydronic-system connections.
 - I. Units must be listed and labeled as having been certified under UL 60335-2-40 safety standards for A2L refrigerants.
- 1.7 WARRANTY
- A. Each unit's parts are warranted to be free from manufacturing defects for up to 1 year from the date of installation.
 - B. Each Unit's compressor is warranted for 5 year from the date of start up. Start up must be done within 90 days of installation. Otherwise the warranty will start from the date of installation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide WaterFurnace T9RS Heat pump or comparable product by one of the following:
1. Aermec
 2. Climacool
 3. Multistack
 4. Or approved equal.

2.2 MODULAR SCROLL AIR TO WATER HEAT PUMPS

- A. Description: Factory-assembled and performance-tested air-source heat pump complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories. Each module shall be capable of supplying chilled water, or hot water. Failure of any module in the bank will not affect the operation of any other module. Any refrigerant circuit failure on a single module shall not affect the operation of the other circuit. Listed as air source heat pump (ASHP) on the schedules.
- B. Operating Characteristics: Ensure that the unit can operate as per the following ambient range and water temps:
1. Cooling mode from 40°F to 120°F ambient outdoor air temperatures while producing (44°F LWT)
 2. Heating mode from -15°F to 65°F ambient outdoor air temperatures while producing (120°F LWT)
 3. Provide propylene glycol per the plans.
- C. Cabinet:
1. Base: Galvanized-steel base extending the perimeter of chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
 2. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.
 3. Casing: Galvanized steel, with field installed louvered panels for ends of bank.
 4. Finish: Powder-coat base, frame, and casing with 500 hour salt-spray tested paint.

D. Scroll Compressors:

1. Description: Positive-displacement direct drive with hermetically sealed casing.
2. Vapor injection compressors with discharge superheat temperature controls.
3. Each compressor provided with suction and discharge service valves, internal stator heating, and suction strainer.
4. Capacity Control: inverter driven.
5. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.
6. Vibration Isolation: Individual compressors mounted on vibration isolators.
7. Compressors must be enclosed in acoustically insulated and weatherproof thick galvanized steel compartment.
8. Compressor compartment must be accessible.

E. Compressor Motors:

1. Hermetically sealed and cooled by refrigerant suction gas.
2. Permanent magnet brushless DC inverter driven with inherent thermal-overload protection and capability to reset compressor lockout circuit at either remove controls or circuit breaker.
3. Compressor motors must not exceed 15 horsepower.

F. Refrigeration:

1. Refrigerant: R-454B. Classified as Safety Group A2L according to ASHRAE 34.
2. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
3. Refrigerant Circuit: Each circuit shall include a bi-directional thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
4. Each module shall have two refrigeration circuits.
5. Refrigerant Isolation: Factory installed positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.
6. 4-way reversing valve for heating/cooling changeover.

G. Evaporator:

1. Brazed Plate:
 - a. Direct-expansion, single-pass, brazed-plate design.
 - b. Type 316 stainless-steel construction.

- c. Heat exchanger shall have two independent refrigerant circuits, one cooling water circuit
 - d. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
 - e. Insulation: The heat exchangers are to be insulated with $\frac{3}{4}$ " inch thick, 0.27 BTU-in/hr sq.ft. thermal conductivity, expanded closed-cell foam insulation.
 - 2. Evaporator shall be provided with a factory installed inlet strainer.
- H. Water Circuit and Modularity
- 1. Modules must require clearance on only two sides in order to perform all service functions.
 - 2. Each module must be capable of being completely isolated electrically and hydraulically without impacting the operation of the rest of the modules on the set.
 - 3. Headers shall be provided with Victaulic connections between modules. Headers shall be factory installed and incorporated into the frame of the chiller. Headers that run outside the frame of the chiller and/or field installed headers are not acceptable.
 - 4. Shut off valves shall be provided between evaporator and header of each module
- I. Air-Cooled Condenser:
- 1. Refrigerant to air heat exchangers shall utilize enhanced corrugated lanced aluminum fins and rifled aluminum tube construction rated to withstand 600 psig (4135 kPa) refrigerant working pressure. A factory installed drain pan shall be factory installed to direct water away from the unit. AlumiSeal flexible cationic epoxy polymer e-coat uniformly applied to all metallic surfaces with no material bridging between fins. The electro-coat process shall ensure complete HX encapsulation of all conductive surfaces with uniform dry film thickness from 0.5-1.2 mils (12-30 μ m). E-coating shall meet 5B rating for crosshatch adhesion per ASTM B3359. Corrosion durability will be confirmed through testing to no less than 15,000 hours salt spray resistance per ASTM B117 using scribed aluminum test coupons. After e-coat cure, HX shall receive a spray-applied, 2K polyurethane black topcoat to prevent UV degradation of epoxy e-coat film. Topcoat shall have 60 degree gloss (>90%) and dry film thickness of 50-60 μ m.
- J. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
- 1. Fan Motors: Inverter driven totally enclosed nonventilating (TENV) or totally enclosed air over (TEAO) enclosure, with permanently lubricated bearings, with

external overcurrent- and thermal-overload protection. ECM motor with integral drive for variable speed operation with axial fan blades that are constructed of all aluminum with an owl design and dynamically balanced shall be factory mounted.

2. Fan Housing: The fan housing shall be corrosion resistant to meet or exceed 500 hrs Salt Spray test and shall be UV-resistant. The enhanced polymer fan housing and diffuser with guide vanes shall result in increased directional air flow while minimizing horizontal focused acoustic sound pressure.
- K. Integral Water Piping Headers: The unit shall have dedicated 6" diameter headers for the supply and return water connected to the dedicated evaporator for chilled water and a separate header for the supply and return water connected to the dedicated condenser for hot water. The supply water connections between the header and the brazed plate heat exchangers shall include a manual butterfly valve for isolation while the return water connections between the header and the brazed plate heat exchangers shall include a modulating butterfly valve for isolation and water flow control by the unit controls. The maximum operating pressure of the water piping is 150 psig.
- L. Connections:
1. Water connections: The unit shall have one set of entering and leaving water connections for hot water and a set for chilled water. Connection types shall be
 - a. Grooved: Grooved mechanical fitting rated for use with carbon steel piping. Gaskets shall be Grade "E" EPDM
 - b. Flanged: Flanged mechanical fitting rated for use with carbon steel piping. Gaskets shall be Grade "E" EPDM.
 2. Drain Pan Connections : stainless steel 3/4" NPT.
- M. Bypass assemblies: Chilled and hot water bypass assemblies shall be factory supplied and field installed consisting of a modulating 2-way butterfly water isolation valves, inlet & outlet temperature sensors, and differential water pressure transducers. The water bypass assemblies shall be controlled in conjunction with the internal water isolation valves for efficient operation in a variable primary system.
- N. Defrost
1. Modules shall be provided with an integral heat traced defrost condensate drip tray. Heat traced piping from drip trays to roof drain as shown on the Plans shall be furnished and installed by others.
 2. The units must include intelligent defrost. This allows the unit to go in defrost only when is needed, avoiding unnecessary defrost cycles. This shall be achieved by monitoring the suction pressure decay and the OAT.
 3. Timed defrost is not allowed.

4. Heat pumps performance and efficiency should take into consideration of defrost cycles.
5. Defrost cycle should not usually be less than 2 minutes and not more than 6 minutes.
6. During defrost cycle, condenser fan should be off.
7. Defrost will start only when external air temperature is less than 50F.
8. Low pressure threshold on the coil should be less than 5.2 bar/75.42 Psi.
9. When the pressure variations between clean and uncleaned coil is 0.6 bar/8.70 psi, defrost will start automatically.
10. Minimum time between two defrost should be greater than 15 minutes

O. Electrical Power:

1. Bank: Each bank of modules shall be shipped to the field on a common base rail with a bank single point power connection. Bank single point power shall provide power for each module, as well as the Supervisory Controller.
2. Raceways: Line voltage power panel with each point of power shall be installed in galvanized raceways. All wiring and enclosures shall be NEMA 4 rated.
3. Modules: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point power connection to each module.
4. Electrical enclosure shall be mounted so as to maximize serviceability to components located behind.
5. Wiring shall be numbered and color-coded to match wiring diagram.
6. Field power interface shall be heavy-duty, nonfused disconnect switch.
7. Provide each motor with overcurrent protection.
8. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
9. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
10. Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate controls
11. Control Relays: Auxiliary and adjustable time-delay relays.
12. Indicate the following for water chiller electrical power supply:
 - a. Current, phase to phase, for all three phases.
 - b. Voltage, phase to phase and phase to neutral for all three phases.
 - c. Three-phase real power (kilowatts).
 - d. Three-phase reactive power (kilovolt amperes reactive).
 - e. Power factor.
 - f. Running log of total power versus time (kilowatt hours).
 - g. Fault log, with time and date of each.

P. Controls:

1. Provide factory-mounted and factory-wired controls for sequenced operation of compressors, refrigerant circuit control valves, and axial fan motors. Low

voltage control shall be 24-volt class 2, minimum 75VA transformer with integral Class CC circuit breaker. Provide safety lockout control with refrigerant high-pressure switch and water freeze protection on both the evaporator and condenser brazed plate heat exchangers. The lockout circuit shall be capable of being reset by either resetting the low voltage power supply or the main unit circuit breaker. Unit shall have as a standard phase loss/reversal monitor for compressor and fan motor protection.

2. Modular Microprocessor Control: Provide a factory installed HydroLink2, microprocessor control that sequences all unit functions and modes of operation through the Advanced Aurora controls. The control shall be capable of interface with a building automation controller using BACnet IP communication protocols.
3. HydroLink2 Supervisory Controller:
 - a. The HydroLink2 controller shall be based upon the Niagara N4 framework with an OEM license that doesn't need to be renewed for the service life of the product.
 - b. The HydroLink2 supervisory controller shall be capable of integrating up to 10 chiller modules using the Niagara internal integration method.
 - c. Provide a factory installed color touch screen HMI. The 10" HMI shall be capable of displaying in clear, English text and graphics:
 - 1) Entering and leaving water temperatures at each brazed plate heat exchanger
 - 2) exchanger
 - 3) Discharge refrigerant pressure and saturated temperature values
 - 4) Suction refrigerant pressure and saturated temperature values
 - 5) Superheat and subcooling values
 - 6) Electrical energy consumption
 - 7) Modular chiller modes and control status
 - 8) Modular chiller compressor accumulated runtime
 - d. NEMA 4 rated enclosure with 115Volt GFCI convenience outlet powered through a step-down transformer or a dedicated building electrical circuit.
 - e. System control points/components and bypass assemblies
4. Control Functions:
 - a. Manual or automatic startup and shutdown time schedule.
 - b. Entering and leaving chilled-water temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on a command from the BMS.
 - c. Current limit and demand limit.
 - d. External water heat pump emergency stop.
 - e. Antirecycling timer.
 - f. Automatic lead-lag switching.
5. Manual-Reset Safety Controls: The following conditions shall shut down water heat pump and require manual reset:
 - a. Low evaporator pressure or high condenser pressure.
 - b. Low chilled-water temperature.
 - c. Refrigerant high pressure.
 - d. High or low oil pressure.

- e. High oil temperature.
- f. Loss of chilled-water flow.
- g. Control device failure.

Q. Insulation:

1. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
2. Thickness: $\frac{3}{4}$ Inch
3. Factory-applied insulation over cold surfaces of water chiller components.
 - a. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
4. Apply protective coating to exposed surfaces of insulation.

R. Pre-Fabricated Skid: Modules shall ship to local riggers yard mounted on a single skid constructed as specified below:

1. TYPE B-7 Steel Frame
 - a. Steel members of sufficient strength to prevent equipment flexure during operation.
 - b. Height saving brackets as required to reduce operating height.
 - c. Rails shall include the following features:
 - d. Rails shall be manufactured from C8x11.5# galvanized steel channel, reinforced and cross braced as required.
 - e. Springs shall have all of the features of TYPE B isolator.
 - f. The Rail shall maintain the same installed and operating height with or without the equipment load and shall be capable of being utilized as a blocking device.
 - g. Rail shall be assembled at the factory and shipped as one bank.
 - h. Framed designed for rigging with units installed. Frame rigging analysis to be provided by supplier.
 - i. Frame is to be extended to accommodate a power panel on each end of the bank.
2. Type B Spring Isolators:
 - a. Shall be the same as TYPE B with the following features:
 - b. Spring shall have a minimum outer diameter to overall height ratio of 0.8: 1 at rated deflection.
 - c. Reserve deflection (from published load ratings to solid height) of 50% of the rated deflection.
 - d. Minimum $\frac{1}{4}$ " thick neoprene acoustical base pad or cup on underside, unless designated otherwise.
 - e. Integral restraining bolts with elastomeric cushions preventing metal-to-metal contact.
 - f. Internal spring adjusting nut or bolt.
 - g. Built-in all-directional limit stops with minimum $\frac{1}{8}$ " clearance under normal operation.
3. Electrical:

- a. Modules shall ship fully wired on pre-fabricated skid. There shall be there shall be a single point of power for the total skid.
- b. There is to be no reconnecting of wiring required on site.
- c. All wiring shall be installed in raceways which are NEMA 4 rated.
- d. All electrical enclosures shall be NEMA 4 rated.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electric installations for air-source heat pumps to verify actual locations of piping connections and electrical conduits before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Equipment Mounting:
 - 1. Install air-source heat pumps on pre-fabricated base rail, common for each bank.
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.3 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
 - 1. Connect supply and return hydronic piping to heat pump with unions and shutoff valves.
 - 2. Connect heat-pump condensate drain pan to indirect waste connection with condensate trap of adequate depth to seal against fan pressure. Install cleanouts in piping at changes of direction.
- B. Install electrical devices furnished by manufacturer but not specified to be factory mounted.
- C. Install piping adjacent to machine to allow service and maintenance.

- 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."

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following field tests and inspections:
 - 1. After installing air-source heat pumps and after electrical circuitry has been energized, test units for compliance with requirements.
 - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 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. Heat pumps will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Complete installation and startup checks according to manufacturer's written instructions and do the following:
 - 1. Inspect for visible damage to unit casing.
 - 2. Inspect for visible damage to compressor, coils, pumps and fans.
 - 3. Inspect internal insulation.
 - 4. Verify that labels are clearly visible.
 - 5. Verify that clearances have been provided for servicing.
 - 6. Verify that controls are connected and operable.
 - 7. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
 - 8. Verify that pumps are installed and functional.
 - 9. Verify that thermometers and gages are installed.

10. Adjust vibration isolators.
11. Verify bearing lubrication on fan.
12. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
13. Adjust fan belts to proper alignment and tension.
14. Start unit according to manufacturer's written instructions.
15. Complete startup sheets and attach copy with Contractor's startup report.
16. Inspect and record performance of interlocks and protective devices; verify sequences.
17. Operate unit for an initial period as recommended or required by manufacturer.
18. Verify thermostat and humidistat calibration.
19. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
20. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
21. Start refrigeration system, and measure and record the following:
 - a. Coil leaving-water temperatures.
 - b. Coil entering-water temperatures.
 - c. Outdoor-air, dry-bulb temperature.
 - d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
22. Measure and record the following minimum and maximum airflows. Plot pump volumes on pump curve.
 - a. Supply-water volume.
 - b. Return-water volume.
 - c. Outdoor-air intake volume.

3.6 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. 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.

3.7 CLEANING

- A. Clean strainers used during construction prior to balance or Substantial Completion.

- B. After completing installation of exposed, factory-finished, air-source heat pumps, inspect exposed finishes and repair damaged finishes.

3.8 DEMONSTRATION

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

END OF SECTION 238146.15

SECTION 23 82 23

ELECTRIC RADIANT HEATERS

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

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: prefabricated radiant-heating electric panels.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. 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.

ELECTRIC RADIANT HEATERS

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- C. 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 MANUFACTURER

- A. Manufacturers: Subject to compliance with requirements, provide products as follows or approved equal, subject to compliance with all specified requirements:
 - 1. Indeeco
 - 2. Runtal North America
 - 3. QMark / Marley

2.2 CONSTRUCTION

- A. Casing & Waterway:
 - 1. Radiator shall be of a welded steel, one-piece panel construction with a slim profile (nominal 2-1/4" depth).
 - 2. Radiator shall be designed to provide both radiant and convective heat.
 - 3. Unit shall have a low surface temperature.
- B. Heating element:
 - 1. Factory-installed electric resistance heating element, concealed within the radiator assembly.
- C. Finish:
 - 1. All surfaces shall be treated and finished with a durable, non-toxic powder-coat finish.
 - 2. Custom color as selected by Architect.
- D. Mounting:
 - 1. Unit shall be designed for wall-mounting and include the manufacturer's standard mounting hardware.

2.3 COMPONENTS

A. Heating:

1. Voltage: 208V, 60Hz, 1-Phase.
2. Unit shall be hard-wired (Direct Wire).
3. Provide integral junction boxes on both ends of the unit to allow for wiring flexibility and easy connection of multiple units in parallel.

B. Safety Controls:

1. Unit shall be UL Listed.
2. Provide integral, automatic-reset high-limit thermal cutout for over-temperature protection.

2.4 CONTROLS AND SAFETIES

A. General:

1. All controls shall be factory-wired, pre-assembled in an integral control panel, and tested.
2. Unit shall be configured for a single-point power connection.

B. Control Circuit:

1. Units shall be controlled by an integral, unit-mounted thermostat.
2. A remote, wall-mounted thermostat shall be provided to monitor thru the BAS.
3. All control, operation, scheduling, and temperature setpoints shall be by the BAS, as specified in Section 23 09 23 "Direct Digital Control (DDC) System for HVAC".

C. Safety Controls:

1. Automatic Reset High-Limit: An automatic-reset thermal cutout shall be provided to shut off the heater in the event of overheating and reset automatically when temperatures return to normal.
2. Manual Reset High-Limit: A secondary, manual-reset thermal cutout shall be provided as a backup to de-energize all elements and require a manual reset in the event of a persistent fault.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive electric baseboard radiators 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 radiator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. INSTALLATION

- 1. Install electric baseboard radiators in accordance with manufacturer's written instructions and all applicable codes.
- 2. Mount units securely, ensuring all specified clearances to floor and combustible materials (e.g., drapes) are maintained.
- 3. Install units level and plumb, with adequate space for service and maintenance.
- 4. Install remote thermostats in locations as indicated on the drawings, at 48 inches (1220 mm) above the finished floor.

B. CONNECTIONS

- 1. Make electrical power connections to the electric baseboard radiator in accordance with NFPA 70. Verify supply voltage matches the unit nameplate (208V).
- 2. Make all control connections between the BAS (DDC) system and the remote control relay.

C. STARTUP & TESTING

- 1. After installation, verify all controls and safety cutouts are functioning correctly.
 - 2. Energize unit and confirm proper operation through a full heating cycle.
- D. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

- E. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 238223

SECTION 23 82 39.19

WALL AND CEILING UNIT HEATERS

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General Conditions of Division 1, State of Connecticut, Department of Transportation, Standard Specifications for Roads, Bridges, Facilities and Incidental Construction, Form 819 - 2024 and supplemental specifications thereto, shall be a part of this specification.

1.2 SUMMARY

- A. Section Includes: Heavy-duty, industrial-grade electric unit heaters for wall and ceiling mounting.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. 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.
- C. 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 MANUFACTURER

- A. Manufacturers: Subject to compliance with requirements, provide products as follows or approved equal, subject to compliance with all specified requirements:
1. Indeeco
 2. QMark
 3. Reznor

2.2 CONSTRUCTION

- A. Casing:
1. Fabricated from heavy-gauge (minimum 18-gauge) steel.
 2. Finish: Casing shall be treated and finished with a durable, corrosion-resistant powder-coat finish.
- B. Louvers:
1. Individually adjustable, horizontal louvers for airflow direction.
 2. Finish to match unit casing.

2.3 COMPONENTS

- A. Heating Elements:
1. Shall be high-quality, finned tubular elements.

2. Elements shall consist of a steel sheath with steel fins continuously brazed to the sheath to ensure maximum heat transfer.
3. Elements shall be non-glowing and fully enclosed within the unit casing, isolated from the airstream.

B. Motor and Fan Assembly:

1. Motor: Heavy-duty, totally enclosed (TEFC), and permanently lubricated. Motor shall have built-in thermal overload protection.
2. Fan: Axial flow fan, dynamically balanced for quiet operation.
3. Fan Guard: Heavy-gauge steel fan guard to prevent contact with the fan blade.
- C. Mounting Bracket:
 4. Unit shall be supplied with a universal mounting bracket suitable for wall or ceiling mounting.
 5. Bracket shall allow for horizontal and vertical adjustment of the unit.

2.4 CONTROLS AND SAFETIES

A. General:

1. All controls shall be factory-wired, pre-assembled in an integral control panel, and tested.
2. Unit shall be configured for a single-point power connection.

B. Control Circuit:

1. Units with a supply voltage of 480V (3-Phase) or 277V (1-Phase) shall include an integral, step-down transformer to provide a 24V (or 120V) low-voltage control circuit for all controls.
2. Units shall be controlled by an integral, unit-mounted thermostat.
3. A remote, wall-mounted thermostat shall be provided to monitor thru the BAS.
4. All control, operation, scheduling, and temperature setpoints shall be by the BAS, as specified in Section 23 09 23 "Direct Digital Control (DDC) System for HVAC".

C. Contactors:

1. Shall be heavy-duty, magnetic contactors rated for the full heater load.

D. Safety Controls:

1. Automatic Reset High-Limit: An automatic-reset thermal cutout shall be provided to shut off the heater in the event of overheating and reset automatically when temperatures return to normal.

2. Manual Reset High-Limit: A secondary, manual-reset thermal cutout shall be provided as a backup to de-energize all elements and require a manual reset in the event of a persistent fault.

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 OF WALL AND CEILING UNIT HEATERS

A. INSTALLATION

1. Install unit heaters in accordance with manufacturer's written instructions and all applicable codes.
2. Mount units securely using the provided brackets, ensuring all specified clearances to combustible materials are maintained.
3. Install units level and plumb, with adequate space for service and maintenance.
4. Install remote thermostats in locations as indicated on the drawings, at 48 inches (1220 mm) above the finished floor.

B. CONNECTIONS

1. Make electrical power connections to the unit heater in accordance with NFPA 70.
2. Make all control connections between the unit heater and remote thermostat (if applicable).

C. STARTUP & TESTING

1. After installation, verify all controls and safety cutouts are functioning correctly.
2. Verify fan rotates freely and in the correct direction.

3. Energize unit and confirm proper operation through a full heating cycle.
 4. Adjust louvers to direct airflow as required.
- D. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- E. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 238239.19

SECTION 23 83 16

RADIANT-HEATING HYDRONIC PIPING

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. PEX pipe and fittings.
2. Distribution manifolds.
3. Piping specialties.
4. Controls.

1.2 DEFINITIONS

- A. CWP:** Cold working pressure.
- B. PEX:** Crosslinked polyethylene.
- C. PTFE:** Polytetrafluoroethylene plastic.

1.3 ACTION SUBMITTALS

A. Product Data:

1. PEX pipe and fittings.
2. Distribution manifolds.
3. Piping specialties.
4. Controls.
5. For each product, provide the following:

- a. Data for piping, fittings, manifolds, specialties, and controls; include pressure and temperature ratings, oxygen-barrier performance, fire-performance characteristics, and water-flow and pressure-drop characteristics.
- B. Shop Drawings: Show piping size, layout, and details drawn to scale, including valves, manifolds, controls, and support assemblies, and their attachments to building structure.
 - 1. Shop Drawing Scale: 1/4 inch = 1 foot (1:50).

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Piping layout, or Building Information Model (BIM), drawn to scale, showing the items described in this Section and coordinated with all building trades.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For radiant-heating piping valves and equipment to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PEX PIPE AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Uponor Inc.
 - 2. Viega LLC.
 - 3. Watts Radiant
- B. Pipe Material: PEX plastic in accordance with ASTM F876.
- C. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) in accordance with DIN 4726.
- D. Fittings: ASTM F1960, cold expansion fittings and reinforcing rings.

- E. Pressure/Temperature Rating: Minimum 90 psig (620 kPa) and 180 deg F (82 deg C).

2.2 DISTRIBUTION MANIFOLDS

- A. Manifold: Minimum NPS 1 (DN 25), stainless steel.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. FloorHeat LLC.
 - c. Infloor Radiant Heating Inc.
 - d. Viega LLC.
- B. Main Shutoff Valves:
 - 1. Factory installed on supply and return connections.
 - 2. Two-piece body.
 - 3. Body: Brass or bronze.
 - 4. Ball: Nickel-plated bronze.
 - 5. Seals: PTFE.
 - 6. CWP Rating: 125 psig (860 kPa).
 - 7. Maximum Operating Temperature: 180 deg F (82 deg C).
- C. Manual Air Vents:
 - 1. Body: Bronze.
 - 2. Internal Parts: Nonferrous.
 - 3. Operator: Key furnished with valve or screwdriver bit.
 - 4. Inlet Connection: NPS 1/2 (DN 15).
 - 5. Discharge Connection: NPS 1/8 (DN 6).
 - 6. CWP Rating: 125 psig (860 kPa).
 - 7. Maximum Operating Temperature: 180 deg F (82 deg C).
- D. Balancing Valves:
 - 1. Body: Plastic or bronze, ball or plug, or globe cartridge type.
 - 2. Ball or Plug: Brass or stainless steel.
 - 3. Globe Cartridge and Washer: Brass with EPDM composition washer.
 - 4. Seat: PTFE.
 - 5. Visual Flow Indicator: Flow meter with visible indication in a clear plastic cap at top of valve.

6. Differential Pressure Gauge Connections: Integral seals for portable meter to measure loss across calibrated orifice.
 7. Handle Style: Lever or knob, with memory stop to retain set position if used for shutoff.
 8. CWP Rating: Minimum 125 psig (860 kPa).
 9. Maximum Operating Temperature: 180 deg F (82 deg C).
- E. Zone Control Valves:
1. Body: Plastic or bronze, ball or plug, or globe cartridge type.
 2. Ball or Plug: Brass or stainless steel.
 3. Globe Cartridge and Washer: Brass with EPDM composition washer.
 4. Seat: PTFE.
 5. Actuator: Replaceable electric motor.
 6. CWP Rating: Minimum 125 psig (860 kPa).
 7. Maximum Operating Temperature: 180 deg F (82 deg C).
- F. Thermometers:
1. Mount on supply and return connections.
 2. Case: Dry type, metal or plastic, 2-inch (50-mm) diameter.
 3. Element: Bimetal or other type of temperature element.
 4. Movement: Mechanical, connecting element and pointer.
 5. Stem: Stainless steel.
 6. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
 7. Pointer: Black metal.
 8. Window: Plastic.
 9. Connector: Rigid, back type.
 10. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.
- G. Mounting Brackets: Copper, or plastic- or copper-clad steel, or stainless steel, where in contact with manifold.

2.3 PIPING SPECIALTIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Uponor Inc.
 2. Viega LLC.

3. Watts Radiant

B. Cable Ties:

1. Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
2. Minimum Width: 1/8 inch (3 mm).
3. Tensile Strength: 20 lb (9 kg), minimum.
4. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).

C. Floor-Mounting Staples:

1. Plastic, U-shaped, PEX-fastening staples designed for installation with a staple gun.
2. Shall be non-metallic and designed to not damage the PEX tubing.
3. Length as required for a minimum of 1-inch (25-mm) embedment into the insulation board.

D. Floor-Mounting Tracks:

1. Plastic channel track with smooth finish and no sharp edges.
2. Designed to be laid on the substrate.
3. Slot Width: Snap fit to hold tubing.
4. Slot Spacing: 2-inch (50-mm) or 3-inch (75-mm) intervals.

2.4 CONTROLS

A. Temperature-control devices and sequence of operations are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC".

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

1. Uponor Inc.
2. Viega LLC.
3. tekmar; A WATTS Brand.

C. Wall-Mounted / Slab Thermostat:

1. Minimum temperature range from 30 to 90 deg F.
2. Manually operated with on-off switch.
3. Day and night setback and clock program with minimum four periods per day.

4. Operate pumps or open zone control valves if room temperature falls below the thermostat setting, and stop pumps or close zone control valves when room temperature rises above the thermostat setting.
 - a. Retain "Precipitation and Temperature Sensor" Paragraph below to operate radiant-heating panel for snow melting on pavement.
 - b.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces and substrates to receive radiant-heating piping for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 1. Ensure that surfaces and pipes in contact with radiant-heating piping are free of burrs and sharp protrusions.
 2. Ensure that surfaces and substrates are level and plumb.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Install the following types of radiant-heating piping for the applications described:
 1. Piping in Interior Reinforced-Concrete Floors: PEX.
 2. Piping in Level-Fill Unreinforced Concrete Floors: PEX.
 3. Piping in Ceilings and Walls: PEX.

3.3 INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such 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 or coordination drawings.
- B. Install radiant-heating piping continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels.
- C. Connect radiant piping to manifold in a reverse-return arrangement.

- D. Do not bend pipes in radii smaller than manufacturer's minimum bend radius dimensions.
- E. Install manifolds in accessible locations or install access panels to provide maintenance access as required in Section 083113 "Access Doors and Frames."
- F. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties" for pipes and connections to hydronic systems and for glycol-solution fill requirements.
- G. Fire- and Smoke-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials in accordance with Section 078413 "Penetration Firestopping."
- H. Piping in Interior Reinforced-Concrete Floors:
 - 1. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
 - 2. Space cable ties a maximum of 18 inches (457 mm) o.c. and at center of turns or bends.
 - 3. Maintain 2-inch (50-mm) minimum cover.
 - 4. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches (250 mm) on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
 - 5. Maintain minimum 40 psig (275 kPa) pressure in piping during concrete placement and continue for 24 hours after placement.
- I. Piping in Level Fill Concrete Floors (Not Reinforced):
 - 1. Secure piping in concrete floors by attaching pipes to subfloor using tracks, clamps, or staples.
 - 2. Space tracks, clamps, or staples a maximum of 18 inches (457 mm) o.c. and at center of turns or bends.
 - 3. Maintain 3/4-inch (19-mm) minimum cover.
 - 4. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches (250 mm) on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
 - 5. Maintain minimum 40 psig (275 kPa) pressure in piping during the concrete pour and continue for 24 hours during curing.

J. Piping in Ceiling and Walls:

1. Secure piping by attaching pipes to ceiling or wall substrate using clamps or staples.
2. Space clamps or staples a maximum of 18 inches (457 mm) o.c. and at center of turns or bends.
3. Maintain 1-1/2-inch (38-mm) minimum plaster cover.
4. Maintain minimum 40 psig (275 kPa) pressure in piping during the plaster application and continue for 24 hours during curing.

K. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved by Architect.

L. After system balancing has been completed, mark balancing valves to permanently indicate final position.

M. Perform the following adjustments before operating the system:

1. Open valves to fully open position.
2. Check operation of automatic valves.
3. Set temperature controls so all zones call for full flow.
4. Purge air from piping.

N. After concrete or plaster heating panel has cured as recommended by concrete or plaster supplier, operate radiant-heating system as follows:

1. Start system heating at a maximum of 10 deg F (6 deg C) above the ambient radiant-panel temperature and increase 10 deg F (6 deg C) each following day until design temperature is achieved.
2. For freeze protection, operate at a minimum of 60 deg F (16 deg C) supply-water temperature.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections:

1. Prepare radiant-heating piping for testing as follows:
 - a. Open all isolation valves and close bypass valves.
 - b. Open and verify operation of zone control valves.
 - c. Flush with clean water and clean strainers.

2. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - a. Leak Test: After installation, charge system and test for leaks. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than 100 psig (690 kPa). Repair leaks and retest until no leaks exist.
 - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 3. Radiant-heating piping will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.
- D. Protect hydronic piping system from damage during construction.

END OF SECTION 238316

SECTION 23 84 16.16
INDOOR, MECHANICAL DEHUMIDIFICATION UNITS

(Part of Work of Section 23 00 01 – MECHANICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Indoor, mechanical dehumidification units.

1.2 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: For each indoor, mechanical dehumidification unit.

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. Detail fabrication and assembly of dehumidification units.
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.
5. Include diagrams for power, signal, and control wiring.

C. Delegated Design Submittals: For indoor, mechanical dehumidification units.

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.
2. Include design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.3 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Data: Certificates for indoor, mechanical dehumidification units, 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.
- B. Product Test Reports: For each indoor, mechanical dehumidification unit, for tests performed by a qualified testing agency.
- C. Field quality-control reports.
- D. Sample Warranty: For special warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For dehumidification 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. Filters: One set(s) of each type of filter specified.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An NRTL.

1.7 COORDINATION

- A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

1.8 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of indoor, mechanical dehumidification units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Compressors: Manufacturer's standard, but not less than two years from date of Substantial Completion.
 - 2. Warranty Period for Refrigerant Coils: Manufacturer's standard, but not less than five 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. Seismic Performance: Dehumidification units 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 when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 - 2. Component Importance Factor: 1.5.
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
- D. ASHRAE 62.1 Compliance: Section 5, "Systems and Equipment" and Section 7, "Construction and System Start-up."
- E. ASHRAE 15 Compliance: "Safety Standard for Refrigeration Systems."
 - a. INDOOR, MECHANICAL DEHUMIDIFICATION UNITS
- F. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. QUEST.
 - b. Anden.
 - c. Santa Fe.
- G. Casings:
 - 1. Casing: Single-wall construction with interior corrosion-resistant coating and exterior baked-enamel or powder-coated steel, .
 - a. Access: Removable panels for access to internal components (filter, compressor, electrical).

- b. Insulation: Manufacturer's standard internal insulation for sound attenuation and condensation prevention.
 - c. Mounting: Unit shall be capable of suspension from structure or wall-mounting using manufacturer's approved bracket kits.
- 2. Drain Pan and Connection: Stainless steel; insulated and complying with ASHRAE 62.1.
- 3. Condensate Pump: Unit shall include integral or field-installed condensate pump with safety overflow switch (float), capable of lifting condensate to overhead drain piping. Pump shall provide dry-contact alarm output for BMS integration.

H. Fans:

- 1. Type: High-efficiency backward-inclined impeller or centrifugal blower.
 - a. Motor: Electronically Commutated Motor (ECM) or high-efficiency permanent split capacitor (PSC).
 - b. Efficiency: High efficiency, designed for continuous duty.
 - c. Control: Constant speed or Variable speed controlled by onboard logic.
 - d. Filters:
- 2. Pleated:
 - a. MERV Rating: MERV 13, according to ASHRAE 52.2.

I. Refrigeration System:

- 1. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IES 90.1.
- 2. Type:
 - a. Copper tube with aluminum fins (or manufacturer's standard high-efficiency microchannel aluminum)
 - b. Protection: Coils shall be capable of withstanding corrosive environments..
 - c. Compressors: Hermetic scroll or rotary compressor.
 - d. Mounting: Internal vibration isolation grommets.
 - e. Refrigerant: Low-GWP refrigerant (R-454B, R-32, or equivalent <700 GWP) complying with EPA regulations for systems manufactured after Jan 1, 2025.
 - f. Controls:
 - 1) Defrost: Automatic "on-demand" defrost cycle to prevent coil icing during low-temperature operation (down to 40°F).
 - 2) Safety: High-pressure and low-pressure/temperature cutouts.
 - 3) Time Delay: Anti-short-cycle timer to prevent compressor damage.
 - g. Controls:
- 3. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC" for control equipment.
- 4. Onboard Controller:
 - a. Unit shall have integral digital controller for standalone operation.
 - b. Function: Adjustable relative humidity setpoint, fan mode (Auto/On).

5. BMS Integration (Remote Control):
 - a. Unit shall be equipped with a low-voltage (24V) terminal block or external interface for connection to Building Management System (BMS).
 - b. Inputs: Remote "Dehumidify" Enable (Dry Contact).
 - c. Outputs: Alarm/Trouble status (Dry Contact) linked to Condensate Overflow or Compressor Fault.
6. Sensors: Factory-installed sensors for:
 - a. Inlet Air Temperature/Humidity.
 - b. Coil Temperature (Defrost logic).
 - c. Accessories:
7. Hanging Kit: Vibration-isolating suspension kit (chains/brackets) suitable for overhead installation.

2.2 MATERIALS

- A. Steel:
 1. ASTM A653/A653M for galvanized steel sheet.
- B. Corrosion Protection: Casing shall be powder-coated or painted to withstand damp environments.
 - a. SOURCE QUALITY CONTROL
- C. Verification of Performance: Factory test and rate dehumidification units according to AHRI 910.
- D. Sound-Power-Level Ratings: Factory test and rate dehumidification units according to AHRI 575.

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 roughing-in for refrigerant piping systems to verify actual locations of piping connections before equipment installation.
- C. Examine walls, floors, and roofs for suitable conditions where dehumidification units will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF INDOOR, MECHANICAL DEHUMIDIFICATION UNITS

A. Equipment Mounting:

1. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
2. Vibration Isolation: Install spring isolators or neoprene hangers in the suspension rods to prevent vibration transmission to the structure.
3. Leveling: Unit must be installed level in both directions (or slightly pitched toward drain if recommended by manufacturer) to ensure proper gravity drainage of condensate.
4. Clearance: Maintain manufacturer's recommended clearances for service access (filter removal) and airflow intake/discharge.
5. Condensate Piping: Connect condensate drain pan to nearest floor drain or condensate pump.
6. Trap: Install P-trap on drain line if required by manufacturer to prevent air intake through the drain line (negative pressure).
7. Pitch: Install piping with a minimum downward pitch of 1/8 inch per foot (1 percent).

3.3 ELECTRICAL CONNECTIONS

A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

B. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number 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 (13 mm) high.
3. Locate nameplate where easily visible.

3.4 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between control devices.

C. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

A. Testing Agency:

1. Owner will engage a qualified testing agency to perform tests and inspections.
 2. 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. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
 2. Charge refrigerant coils with refrigerant 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.
- D. Dehumidification unit will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.6 CLEANING

- A. Clean dehumidification units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils' entering-air face.
- B. After completing system installation, testing, and startup service of dehumidification units, clean filter housings and install new filters.

3.7 ADJUSTING

- A. Adjust supply and return grilles/louvers (if equipped) for proper air throw.
- B. Adjust initial temperature and humidity set points.

3.8 STARTUP SERVICE

- A. Perform startup service.
1. Complete installation and startup checks according to manufacturer's written instructions.
- B. Perform the following final checks before startup:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Perform cleaning and adjusting specified in this Section.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Check lubrication of bearings, pulleys, belts, and other moving parts.
6. Install clean filters.

C. Starting procedures for dehumidification units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace malfunctioning motors, bearings, and fan wheels.
2. Measure and record motor's electrical values for voltage and amperage.

D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing of dehumidification unit.

E. Startup Report: Report findings during startup. Identify startup steps, corrective measures taken, and final results.

3.9 DEMONSTRATION

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

END OF SECTION 238416.16

SECTION 26 00 01

ELECTRICAL WORK

(Trade Bid Required)

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 the Specifications.
- B. Time, Manner and Requirements for Submitting Trade Bids:
 - 1. Trade bids for work under this Section shall be for the complete work and shall be filed in a sealed envelope with the Owner at a time and place as stipulated in the "INSTRUCTIONS TO BIDDERS".
 - a. The following should appear on the upper left hand corner of the envelope:
 - b. NAME OF TRADE BIDDER: (Insert name of trade bidder)
 - c. TRADE BID FOR SECTION: 26 00 01 - ELECTRICAL WORK
 - d. Each trade bid submitted for work under this Section shall be on forms furnished by the Owner as required by Section 8 of Chapter 149A of the General Laws, as amended. Trade bid forms may be obtained at the office of the Owner.
 - 2. Trade bids filed with the Owner shall be accompanied by BID BOND or CASH or CERTIFIED CHECK or TREASURER'S CHECK or CASHIER'S CHECK issued by a responsible bank or trust company payable to the City of Worcester in the amount of five percent of the trade bid. A trade bid accompanied by any other form of bid deposit than those specified will be rejected.
- C. Trade Sub-Bid Requirements:
 - 1. Section 28 31 11 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM for fire alarm system work.
 - 2. DIVISION 27 - COMMUNICATIONS for communications infrastructure systems work.
 - 3. Section 27 41 00 - CATV DISTRIBUTION SYSTEM for Audiovisual system work.
 - 4. Section 28 00 00 - ELECTRONIC SECURITY GENERAL REQUIREMENTS for Security system work.
 - 5. Section 26 41 13 - LIGHTNING PROTECTION FOR STRUCTURES for lightning protection work.
- D. Reference Drawings: The Work of this Trade Bid is shown on the following Contract Drawings:
 - 1. 01-GENERAL Series

2. 26-ELECTRICAL Series

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. All Work of the following sections:
 - a. 26-ELECTRICAL sections
 - b. Section 270000 - Communications Systems.
 - c. Section 280000 - Security Systems.
 2. Firestopping for the Work of this Section, including cutting penetrations and firestopping; complying with requirements specified in Section 07 84 13 - PENETRATION FIRESTOPPING.
 3. Core drilling for the Work of this Section.
 4. Certified seismic restraints to meet the Commonwealth of Massachusetts Building Code applicable at the time the building permit is issued.
 5. Coordination drawings and record drawings and similar requirements.
 6. CAMIS excel spreadsheet data collection for Equipment Template and PM Procedure tabs as described in Section 01 77 00 - CLOSEOUT PROCEDURES
 7. BIM modeling as specified in this Section and in Section 01 31 06 - COORDINATION DRAWINGS.
- B. Alternates: Not Applicable.
- C. Items to Be Installed Only: Install the following items as furnished by the designated Sections:
1. Section 08 33 23 - OVERHEAD COILING DOORS:
 - a. Controllers, wiring and power connections for overhead coiling doors.
 2. Section 08 36 13 - RESIDENTIAL APPLIANCES:
 - a. Controllers, wiring and power connections for sectional overhead doors.
 3. Section 11 30 00 - PROJECTION SCREENS:
 - a. Controllers, wiring and power connections for electrically-operated projection screens.
 4. Section 14 21 23 - ELECTRIC TRACTION MRL ELEVATORS:
 - a. Power connections for elevators.
 5. Section 21 00 01 - FIRE PROTECTION:
 - a. Connections to fire alarm system for water flow switches and tamper switches.
 6. Section 22 00 01 - PLUMBING:
 - a. Power connections for water heaters.
 7. Section 23 00 01 - HEATING, VENTILATING AND AIR CONDITIONING:
 - a. Power connections for DDC control panels, pumps, fans, electric unit heaters.
 - b. Magnetic starters.
- D. Items to Be Furnished Only: Furnish the following items for installation by the designated Sections:
1. Section 03 30 00 - CAST-IN-PLACE CONCRETE:

- a. Lintels, sleeves, anchors, inserts, plates and similar items for electrical systems.
 2. Section 04 20 00 – UNIT MASONRY:
 - a. Elevator rail bracket inserts.
 - b. Access doors in masonry openings.
 3. Section 09 29 00 - GYPSUM BOARD ASSEMBLIES:
 - a. Access doors in gypsum board assemblies.
 4. Section 09 30 00 - TILING:
 - a. Access doors in tile.
 5. Section 09 51 13 – ACOUSTICAL PANEL CEILINGS:
 - a. Access doors in acoustical tile.
 6. Section 23 00 01 - HEATING, VENTILATING AND AIR CONDITIONING:
 - a. Duct smoke detectors and sampling tubes.
- E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
1. Section 03 30 00 - CAST-IN-PLACE CONCRETE for interior concrete equipment pads and installation of backboxes and conduit for electrical devices and light fixtures.
 2. Section 05 12 00 - STRUCTURAL STEEL FRAMING for structural supports necessary to distribute loading from equipment to roof or floor.
 3. Section 06 10 00 - ROUGH CARPENTRY for plywood packing panels.
 4. Section 08 71 00 - DOOR HARDWARE for coordination with electrified door hardware.
 5. Section 09 29 00 – GYPSUM BOARD ASSEMBLIES for coordination with gypsum ceilings.
 6. Section 09 51 13 – ACOUSTICAL PANEL CEILINGS for coordination with acoustical ceilings.
 7. Section 23 00 01 – HEATING, VENTILATING AND AIR CONDITIONING for coordination with HVAC piping and ductwork, motors, and DDC wiring except 120 VAC power to control panel as indicated on the Drawings
 8. Section 31 00 00 – EARTHWORK for excavation and backfilling for underground work.
- F. The Electrical Trade Contractor shall be responsible for filing all documents, payment of all fees, and securing of all inspections and approvals necessary for the electrical work.
- G. The Electrical Trade Contractor shall carry in the bid price all Utility Company and Municipal backcharges for all materials furnished and work performed by them in conjunction with this Contract and pay same to the respective agency upon demand. The Electrical Trade Contractor shall not be entitled to additional compensation after the submittal of his bid price should he fail, for any reason, to obtain the total backcharge costs to be incurred by the local utility companies or municipal agencies.

END OF SECTION

SECTION 26 05 00

COMMON WORK RESULTS FOR ELECTRICAL

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Where General and Supplement Conditions and General Requirements clauses are repeated in these Specifications, it is to call special attention to them, or as a further qualification. No General and Supplement Conditions and/or General Requirements clause referring to the work of this Section shall be considered waived unless specifically stated herein.
- B. Unless otherwise shown on the Contract Drawings, or unless otherwise specified in other Sections of these Specifications, the requirements specified in this Section are applicable to all electrical work of this Contract. Additional requirements applicable to individual Sections of these Specifications are specified in those Sections, or are shown on the Contract Drawings.
- C. The Specifications and Contract Drawings shall form part of the Contract Documents.

1.2 SUMMARY

- A. Provide all labor, materials, supplies, tools, machinery, equipment, scaffolding, transportation, rigging, storage, utilities, supervision and required permits and licenses necessary to complete the electrical work under this contract.
- B. Provide a complete working electrical installation with all equipment called for in proper operating condition. Documents do not undertake to show or list every item to be provided. When an item not shown or listed is clearly necessary for proper operation of equipment that is shown or listed, provide the item, which will allow the system to function properly at no increase in Contract Price.
- C. Coordinate the electrical work with the work of the other trades so as to resolve conflicts without impeding job progress or the construction schedule.
- D. Examine all Contract Documents including these for other trades in order to determine the extent of the Work required to be completed under this Section.

Failure to examine all Contract Documents for this project will not relieve this contractor of the responsibility to perform all the Work required for a complete, fully operational and satisfactory installation.

- E. Bidders are deemed to be aware, on the basis of the background and experience, of materials, which may be required in the discharge of their responsibilities, even though unspecified. Claims for extras for unspecified shoring or supporting materials will not be considered if the need for such materials would have been reasonably obvious to the bidders skilled and experienced in the work to be done and the submittal of a bid shall be deemed a waiver of any such claims.
- F. Provide notice with bid proposal of any concrete or structural work required by this Section that is not indicated on the Structural or Architectural Drawings.

1.3 CODES, STANDARDS, FILING AND PERMITS

- A. The Electrical installation shall comply with the latest revised versions of all applicable laws, rules, regulations, standards, codes and ordinances of the federal, state and local authorities having jurisdiction and other requirements specified in other Specifications and Contract Drawings.
- B. If any of the provisions of the laws, rules, regulations, standards, codes, ordinances and requirements of the Contract Drawings or Specifications is in conflict with one another, the most stringent requirements shall govern.
- C. Nothing in the Contract Drawings or Specifications shall be construed to permit Work not conforming to the applicable laws, ordinances, rules, and regulations. It is not the intent of the Contract Drawings or Specifications to repeat the requirements of codes except where necessary for completeness or clarity. Any modifications required by the above said authorities having jurisdiction shall be made without additional cost to the Owner. Where Contract Drawings and Specifications requirements are in excess of the rules, regulations and code requirements, and are permitted under the code, the Contract Drawings and Specifications shall govern.
- D. All materials and equipment, materials and methods shall comply with all applicable requirements of laws, codes, ordinances, legislations, etc., of all federal, state and local authorities whether listed on the contract documents or not.
- E. Obtain the required permits from the local authorities for this work and pay for all fees required by the local, State, and Federal authorities for permits, inspections and review, including special agency construction and operating permits. Make corrections in the work as required by the Owner's Representative or Inspector to pass all such regulations.

1.4 REFERENCES

- A. American National Standards Institute (ANSI).
- B. Environmental Protection Agency (EPA)
- C. Electrical Industries Association/Telecommunication Industries Association (EIA/TIA)
- D. Factory Mutual (FM)
- E. Illuminating Engineering Society (IES).
- F. Institute of Electrical and Electronics Engineers (IEEE).
- G. National Electrical Code (NEC-NFPA70).
- H. National Electrical Manufacturer's Association (NEMA).
- I. National Fire Protection Association (NFPA).
- J. National Electrical Contractors Association (NECA)
- K. InterNational Electrical Testing Association (NETA)
- L. National Uniform Seismic Installation Guidelines (NUSIG)
- M. Underwriters' Laboratories (UL).
- N. Occupational Safety and Health Administration (OSHA)

1.5 DEFINITIONS

- A. For purposes of these Specifications the following definitions apply:
 - 1. "ARCHITECT": the Architect of record.
 - 2. "ENGINEER": the Engineer of record.
 - 3. "CONTRACTOR": the individual, partnership or corporation to whom the Contract for the work has been awarded.
 - 4. "PROVIDE": to "Furnish" and "Install".
 - 5. "INSTALL": to join; unite; fasten; link; attach; set up or otherwise connect together; complete, tested, and ready for normal satisfactory operation.
 - 6. "FURNISH": to supply all materials, labor, equipment, testing apparatus, controls, tests, accessories, and all other items customarily required for the proper and complete application.
 - 7. "AS DIRECTED": as directed by the Owner's Representative

8. "CONCEALED": embedded in masonry or other construction, installed below slabs, behind wall furring or within double partitions, or installed within hung ceilings.
9. "SUBMIT": submit to the Owner's Representative for review.

1.6 WORK INCLUDED

- A. The Work specified in this Division includes but is not limited to the following systems, equipment, and services:
 1. All work associated with the new incoming electrical service.
 2. Medium voltage switchgear and transformers.
 3. Switchboards, Distribution, and panelboards for lighting and power.
 4. Feeders, sub feeders, and branch circuiting for light, power and control wiring, including connections to all switchboards, transfer switches, panelboards, transformers, motor control centers, motor starter groups, motor control equipment, disconnect devices, outlets, motors and equipment included in these Specifications or indicated on contract drawings.
 5. Furnishing and installation of lighting equipment, lighting fixtures, lamps, contactors, lighting control systems, etc.
 6. Installation and testing of lighting equipment and controls.
 7. Telecommunications empty raceway system.
 8. Complete electrical grounding system.
 9. Lightning protection system with UL Master Label.
 10. Fire Alarm and Smoke Detection System separately specified.
 11. Testing and Balancing Loads.
 12. Furnishing and installation of heating cable for freeze protection of piping.
 13. Installation and testing of the standby/emergency power system including power and control connections.
 14. Installation and testing of automatic transfer switches including all power and control connections.
 15. Installation and wiring of individual motor controllers and motor control centers, including variable speed drives provided by others.

16. Connection of all motors, equipment, interlocks, safety devices, and other components as indicated on the Drawings, including all motor controllers.
17. Furnishing and installing equipment interlock wiring not provided by the Building Automation and Temperature Control (BATC) System
18. Labor and/or standby assistance in commissioning the control and instrumentation systems provided with Building Automation and Temperature Controls Section of the Specification.
19. Wiring and connection to vertical transportation system equipment being specified under other Divisions.
20. Connection of all equipment specified under other Divisions and/or supplied by the Owner.
21. Remove the protective coverings on the lighting fixtures when required by the heating, ventilating and air conditioning air-balancing subcontractor.
22. Miscellaneous items as required for complete and functioning systems as specified herein and indicated on the Drawings.
23. Provide all excavation and back-fill required for Work of this Division.
24. Supports, vibration isolation and seismic restraint devices.
25. Furnish and set all sleeves complete with seals and firestops as specified herein and as required by the Authority having jurisdiction for the passage of conduit, etc. through structural steel, decking, masonry and concrete walls and floors, drywall construction, any other rated construction assembly, and elsewhere as will be required for the proper protection of each raceway passing through a wall, floor, etc. Coordinate the work with the work of other Trades in order to properly expedite and perform the work. Furnish shop drawings showing the size and location of all required holes through the concrete floors and walls.
26. Participate in and assist in the testing, operation and commissioning of all electrically powered equipment as required during the performance testing and startup of the work of other Sections. Refer to other Sections for additional requirements.
27. Instruments as required for operating and testing the various systems shall be furnished and installed complete as specified herein.
28. Owner's personnel shall be fully instructed regarding operation and maintenance of the entire installation and complete printed or typed instruction booklets shall be provided covering maintenance, operation, and

adjustment of each piece of equipment. Spare parts lists for each piece of equipment shall be furnished.

29. Provide smoke detector elements in the ductwork in cutouts specified under another Section of the Specifications. Closely coordinate the installation of all smoke detector elements with the work of the Heating, Ventilating and Air Conditioning Section of the Contract Documents.
30. Complete all tests required by all rules, regulations, etc. of all authorities having jurisdiction and prepare, complete and file all forms, tabulations, plans, etc., including Controlled Inspections, pertinent thereto with the referenced authorities and accomplish such work with personnel of proper caliber, in particular Professional Engineers, where so required.
31. Participate in and provide labor for "off hour" testing of equipment and systems as required by working conditions or by the Authorities Having Jurisdiction to obtain all "Temporary Certificate of Occupancy (TCO)" and final "Certificate of Occupancy".
32. The Contractor shall provide a minimum of 75% diesel fuel required for initial fill of the emergency power system upon completion of installation, for testing as specified and as required by the authorities having jurisdiction, and to refill the fuel oil tank upon Project completion and prior to Substantial Occupancy.
33. Patching or replace all fireproofing if it is damaged or removed during the installation of the Electrical Work.
34. Furnish required access doors in general construction for access to equipment and systems specified in this Division.
35. Power and empty raceway system for the security system components (refer to Security Consultant's drawings and specifications).
36. Conduit, raceways, ladder racks, sleeves, etc., for the telecommunication systems.
37. Power and empty raceway system for the Audio Visual system (Refer to Audio Visual drawings and specifications).

1.7 SUBMITTALS

- A. Submit detailed and fully coordinated shop drawings showing all conduit routes, equipment with nameplate, devices and pull boxes for each floor including all the Electrical Rooms. The Electrical Rooms shall be shown with large-scale layout shop drawings.

- B. Submit manufacturer's data, shop drawings and samples as noted of all proposed equipment including but not limited to the following:

Switchboards	Power Monitoring System
Disconnect switches	Panelboards
Surge protection devices	Fire Alarm System
Automatic Transfer Switches	Fuses
Luminaires	Circuit Breakers
Lighting Control System	MV Transformer
Lightning Protection System	Power conductors and table
Grounding Equipment	Generator
Floor Boxes and Junction Boxes	Transformers
MV Switchgear	Wiring Devices
Layout of all Electrical Rooms	Routing of all Conduit 2" & Above

- C. Submit detailed and fully coordinated large-scale layout shop drawings showing the sections of all congested areas to show relative position and spacing of the effected elements.
- D. The large-scale layout shop drawings shall be a minimum of 3/8 in. equal to 1 ft. scale.
- E. Submit calculations where required by the Specifications or the Contract Drawings.
- F. Submit detail designs for seismic restraint and support for conduits and equipment. The designs shall be certified and sealed by a Professional Engineer licensed in the State in which the work is to be performed.
- G. Submit certified test reports and trip setting of overcurrent and overload devices where required by the Specifications or the Contract Drawings.
- H. All symbols and designations used in preparing Record and Coordination Drawings shall match those used in the Contract Drawings.
- I. Prior to Final Acceptance, the following data shall be furnished to the Owner's Representative:
1. Record Drawings.
 2. Coordination Drawings

- 3. Operation and Maintenance Manuals
- 4. Manufacturer's Data of the equipment and devices installed

- J. The commissioning process requires Submittal review simultaneously with Engineering review. Division 1 is alerted to the Submittal review requirements in Section 01 91 00.

1.8 QUALITY ASSURANCE

- A. All workmen performing under this Division shall be skilled workers of the trade involved. Where specialty work, such as splicing or welding are required, submit proof of training, experience and work history for each workman, for review by the Owner's Representative. Only properly qualified and certified workmen shall perform specialty work.
- B. All electrical work shall be performed by an electrical contractor licensed in the state (and the city as required) in which the work is to be performed.
- C. All electrical materials and equipment for which there is a nationally recognized standard shall bear the conformance labeling of an independent testing laboratory, such as Underwriters Laboratories Inc., Factory Mutual, ETL or other agency recognized by the local Authority having jurisdiction.
- D. Carcinogenic material, including Asbestos shall not be furnished or installed.
- E. All calculations required by this and other various Sections of these Specifications, or as shown on the Drawings, shall be certified and sealed by a Professional Engineer licensed in the state in which the work is to be performed, and shall be submitted to the Owner's Representative for review.
- F. With the exceptions as specified and/or indicated on the Drawings or in the Specifications, the Contractor shall apply, install, connect, erect, use, clean, commission and condition manufactured articles, materials, and equipment per Manufacturer's current printed instructions and recommendations. Copies of such printed recommendations shall be kept at the Project site and made available as required.
- G. Where the manufacturer's recommendations conflict with the Contract Documents, the conflict shall be brought to the attention of the Owner's Representative's immediately.

1.9 GUARANTEE

- A. Submit a single guarantee stating that all portions of the work are in accordance with Contract Documents. Warrant all work against faulty and improper material

and workmanship for a period of one year from date of substantial completion, except that where guarantees or warranties for longer terms are specified herein, such longer term shall apply. At no additional cost to Owner, within 24 hours after notification, correct any deficiencies, which occur during the warranty period (including all parts, material, labor, etc.), all to the satisfaction of the Owner or his designated representative. In default thereof, the Owner may have such work done and charge all costs to the Contractor. This Contractor shall require similar guarantees from his Subcontractors.

- B. During the warranty period, the Contractor shall guarantee the following in a form satisfactory to the Owner:
 - 1. All equipment will develop capacities and performance characteristics specified.
 - 2. The systems shall operate without malfunction.
- C. The start of the Contractor's warranty period shall commence on the issue of a "Certificate of Substantial Completion", by the Owner's Representative for each item of material, equipment, or system.
- D. The Subcontractor shall confer with the Construction Manager prior to the bid date concerning the project schedule and determine if there is a need to operate any items of equipment or systems for temporary light, power, heating and/or cooling or other reasons prior to "Substantial Completion". All required extended warranty costs for equipment, materials, and systems shall be included in the Contractor's bid.
- E. Warrant that all components, subsystems and systems will perform their specified functions from the date of turnover and commercial operation through the useful life of the system. In the event components fail for any reason, be responsible to repair, replace and reimburse the Owner for all costs associated with the component, subsystem or system that failed to perform the specified function.

1.10 SCHEDULING

- A. The following is a summary of the scheduling milestones described in the text of the Specifications. The Contractor shall start on or schedule the following upon receiving notice to proceed.
 - 1. Immediately upon award of this Contract, this Contractor shall have a pre-construction meeting with the Owner's Representative.
 - 2. On or before three (3) weeks after notice to proceed, submit a complete, typed list of the subcontractors, equipment manufacturers and suppliers they intend to use to the Owner's Representative for review.

3. On or before six (6) weeks after notice to proceed, prepare an index of all his Electrical shop drawings and brochures for the Project.
4. As requested by the Construction Manager, the Contractor shall submit "Coordination Drawings" to the Owner's Representative for review.
5. As requested by the Construction Manager, the Contractor shall provide a detailed schedule of completion indicating when each system is to be completed and outlining when tests will be performed.
6. Submit proposed test procedures, recording forms and test equipment for review by the Owner's Representative prior to execution of testing.
7. Submit six (6) final copies of the Operation and Maintenance books to the Owner's Representative for review at least ten (10) weeks before Final Review of the Project.

1.11 SPACE CONSTRAINT

- A. The equipment selections used in the preparation of the Contract Documents will fit into the physical spaces provided and indicated, allowing room for access, servicing, removal and replacement of parts, etc. Adequate space shall be allowed for clearance in accordance with Code requirements, the requirements of the Authorities Having Jurisdiction, and the equipment manufacturer's recommendations.
- B. In the preparation of Drawings, a reasonable effort to accommodate acceptable equipment manufacturer's space requirements has been made. However, since space requirements and equipment arrangement vary according to each manufacturer, the responsibility for initial access, maintenance access, code required access, and proper fit rests with the Contractor.
- C. Physical dimensions and arrangements of equipment to be installed shall be subject to the Owner's Representative's review.
- D. Wherever possible, electrical equipment distribution and branch lines shall be installed tight to structure.

1.12 DRAWINGS AND COORDINATION WITH OTHER WORK

- A. Contract Drawings
 1. Drawings are essentially diagrammatic, intended to convey the scope of work and to indicate the desired location or arrangement of equipment, devices, conduit runs, outlets, etc and are to be followed as closely as possible. Judgment must be exercised in executing the Work so as to secure the best

possible installation in the available space and to overcome local difficulties due to space limitation or interference with structural conditions.

2. Drawings indicate, diagrammatically, the routes of duct banks and conduit system, unless specifically dimensioned, and do not indicate the required pull boxes, cable support boxes, fittings, seismic restraint, supports or similar items required for a complete system.
3. Exact routing of wiring and locations of outlets, panels, equipment, devices, luminaires, etc., shall be governed by structural conditions, obstructions and existing conditions. Owner's Representative reserves right, at no increase in cost, to make any reasonable change in locations of electrical items, exposed at ceiling and/or on walls, to group them into orderly relationships and/or increase their utility.
4. The Contractor shall follow the Drawings in laying out the Work and check drawings of all trades to verify spaces in which Work will be installed. Maintain maximum headroom in all areas. Where space conditions appear inadequate, the Owner's Representative shall be notified before proceeding with the installation.
5. Work not shown on the Drawings but called for in the Specifications, or vice versa, shall be provided by the Contractor without additional expense to the Owner.
6. Certain materials will be furnished, installed, or furnished and installed, under other Sections of the Contract Documents. Examine the Contract Documents to ascertain these requirements
7. Where variance occurs between the Drawings and Specifications, or within either document itself, the items or arrangement of better quality, greater quantity, or higher cost shall be included in the contract price. The Contractor shall request clarification in writing from the Owner's Representative on which item and manner in which the Work shall be installed.
8. Equipment's location and dimensions shown on the Drawings is approximate of a typical equipment of the class indicated and has been coordinated for structural penetrations, electrical requirements, operating and service requirements, and physical size with regard to the space where the equipment is shown. Other specified manufacturers of this equipment will be acceptable contingent on the Contractor providing a complete installation and maintaining full responsibility to provide, at no additional cost, any modifications to the structure or electrical service that are required to properly install, operate, and service the equipment. These modifications shall not include additional area for the equipment unless agreed to by the Owner's Representative.

9. Locations shown on Architectural Reflected Ceiling Drawings, Architectural Floor Plans or on wall elevations shall take precedence over electrical plan locations. For roughing out devices, the Contractor shall refer to the Architectural Drawings.

B. Coordination:

1. Work out all "tight" conditions involving Work under this Division and Work in other Divisions in advance of installation. If necessary, and before Work proceeds in these areas, prepare supplementary Drawings under this Division for review, showing all Work in "tight" area. Provide supplementary Drawings and additional Work necessary to overcome "tight" conditions.
2. Carefully check space requirements with other Sections of the Contract Documents to insure that all material can be installed in the spaces allotted thereto.
3. Transmit to other Trades information required for work to be provided under other Sections such as space for access to pull boxes, cable support boxes, control wiring and connections, access doors in ample time for installation.
4. The Construction Manager and all Trades shall coordinate the installation of equipment, conduit, busway, ductwork, piping, cable, cable trays, etc., with the installation of luminaires, special ceiling construction, air distribution equipment and the structure. Provide additional rises, drops, offsets and pullboxes as required. If, after installed, new conduit, busway, ductwork, piping or cable is found to be in conflict with the architecture, structure, or other trade Work which is either existing or shown on the Contract Documents, the conduit, busduct, ductwork, piping or cable shall be relocated without additional cost to the Owner.
5. Wherever work interconnects with work of other trades, coordinate this work to insure that other trades are advised of the information necessary so that they may properly install all the necessary connections and equipment. Identify all work items in a manner that the work of other trades may know where to install access doors and panels.
6. Furnish and set all sleeves for passage of the electrical service and distribution, and telecommunication services through structural masonry and concrete walls and floors and elsewhere as will be required for the proper protection of each conduit passing through building surfaces. Coordinate this work with the Construction Manager in order to properly expedite and perform this work and provide fireproofing in accordance with these Contract Documents.

7. A planned sequence of operation is required to properly install the complete systems. It shall be the responsibility of Contractor to coordinate, protect and schedule its work with other trades in accordance with the construction sequence.
8. Architectural drawings shall be checked for ceiling height requirements. Where no ceiling height is stated, request direction from Owner's Representative prior to commencing work.
9. Field drilling, cutting and/or reinforcing of holes in structural metal deck required for work specified in this Division shall be coordinated through the Owner's Representative. All such drilling, cutting and reinforcing costs shall be included as work of the Contract Documents.
10. Differences or disputes concerning coordination, interference or extent of Work between trades shall be decided by Contractor. Contractor's decision, if consistent with Contract Documents requirements, shall be final.
11. Coordinate electrical power and control wiring requirements of mechanical equipment specified in Division 23.
12. Coordinate electrical power and control wiring requirement of Building Management System and Security System with corresponding documentation.
13. Equipment rough-in locations shown on the Drawings for equipment furnished by Owner and for equipment specified under other Divisions are approximate only. Obtain exact rough-in locations from following sources:
 - a. From shop drawings for Contractor-furnished and installed equipment.
 - b. From Owner's Representative for Owner-furnished Contractor-installed equipment.
14. Where conflict exists between rough-in shown on drawings and that shown or required by equipment to be installed, obtain clarification from Owner's Representative and provide rough-in as directed.
15. Provide templates, information and instructions to other Divisions to properly locate holes and openings to be cut or provided for the Work.
16. Cooperate and confer with other trades as to locations of their materials and equipment before erecting work, so as to avoid interference as much as possible, and in such a manner that will in no way retard progress of construction. In the event that interferences develop, the Contractor's decision will be final as to which trade shall relocate its work, and no additional compensation will be allowed for the moving of piping, ductwork, conduit or equipment to clear such interferences.

17. Furnish to appropriate trades, shop drawings, catalog sheets and instructions necessary for construction of concrete bases, concrete encasement, anchor bolts, and other construction required to accommodate installations under other Sections.
18. Before installing electrical work, all pertinent drawings shall be studied and precise information obtained from the architectural schedules, scale drawings, large scale and full size details of finished rooms, reviewed shop drawings or from the Owner's Representative. It shall be understood that even after all the coordination there may be cases where some electrical work, due to the unforeseen site conditions, may required to be relocated within 10 feet from the location shown. In such cases, the Contractor shall relocate the electrical work if so directed by the Owner's Representative at no increase in cost. Make any necessary adjustment of the work to fit conditions for luminaires, switches, fire alarm devices and for outlets occurring in glazed tile, block, wood paneling or other special finish material in order that all boxes shall be flushed with finish and be centered properly. In centering outlets make due allowance for overhead piping, ducts, window and door trim, variations in thicknesses of furring, plastering, etc., as erected, regardless of conditions which may be otherwise shown on small scale drawings. Electrical work incorrectly located shall be properly relocated without expense to the Owner
19. Locate local switches, which are shown near doors at the strike side of the door, unless specifically noted on plans to be beyond the open door.
20. In Mechanical Rooms, Electric Rooms, Elevator Machine Rooms, Pump Rooms, Communications Rooms, etc., light fixture arrangement shall be adjusted to suit the final coordinated equipment, duct, conduits, racks and piping layouts.
21. Coordinate all components and aspects of the work, in order to minimize power shutdowns to the power distribution systems. Should any part of the Work require an "off-hours" shutdown, supply temporary services or feeders to maintain operation of the existing systems and equipment.
22. Coordinate all underground conduit and duct work with Civil drawings.

C. Coordination Drawings

1. The Contractor shall produce a complete set of the "Coordination Drawings" showing electrical, mechanical, plumbing, fire protection, structural and architectural components for the project.
2. The Drawings shall indicate the equipment actually purchased and the exact location of the equipment and the exact routing and elevations for all lines such as piping, busway, conduit, ductwork, etc. All dimensions shall be referenced to building structural centerlines.

3. All Contract Drawing space allocations shall be maintained, such as ceiling height, chase walls, equipment room size, etc., unless prior written authorization is received from the Owner's Representative to change them.
4. The Drawing preparation and completion shall comply with the requirements of the project construction schedule.
5. The Contractor's "Coordination Drawings" indicating piping, conduit, busway, and equipment support points and loads exceeding 500 lb. imposed on the building structure shall be submitted to the Owner's Representative for review. The elevation, location, support points, static, dynamic and expansion forces and loads imposed on the structure at support, and anchor points, and the size of all lines shall be indicated.
6. All beam penetrations and slab penetrations shall be indicated and sized and shall be coordinated. All work routed underground or embedded in concrete shall be indicated by dimension to column and building lines and shall be coordinated. This requirement for "Coordination Drawings" shall not be construed as authorization for the Contractor to make any unauthorized changes to the Contract Drawings.
7. Prepare large scale detailed layout Drawings showing locations of equipment, conduit runs, panels, and all other elements of electrical systems where required by other Sections of this Division, plus sections of all congested areas to show relative position and spacing of affected elements. All symbols and designations used in preparing Record Drawings shall match those used in Contract Drawings.
8. The Work shall be installed in accordance with the shop drawings and the "Coordination Drawings". If the Contractor allows one trade to install their work before coordinating with the work of other trades, the Contractor shall make necessary changes to correct the condition without extra cost to the Owner.
9. Each "Coordination Drawing" shall be completed and signed off by the other trades and the Contractor prior to the installation of the work in the area covered by the specific coordination drawing.

1.13 SHOP DRAWINGS AND SAMPLES

- A. All shop drawings and samples shall be identified as follows
 1. Date of submittal.
 2. Title of project.
 3. Name of Contractor and date of his approval.

4. Name of Subcontractor or supplier and date of submittal to Contractor.
 5. Number of submission.
 6. Any qualification, departure or deviation, item by item, from the requirements of the Contract Documents.
 7. NEMA reference, IEEE Standard, MEA number where required.
- B. The term "shop drawings" shall include layout, detail, and assembly drawings, diagrams, schedules, catalogue sheets, printed descriptive matter, and tabular and graphical presentations of operating and performance data that describe work required by the Contract Documents.
- C. No part of the work shall be started in the shop or in the field until the Owner's Representative has reviewed the shop drawings and samples for that portion of the work and provided the response required. Thereafter, the work shall be executed in accordance with the Contract Documents and the indicated status of the reviewed shop drawing.
- D. Shop drawings and samples shall be submitted for review sufficiently in advance of the scheduled start of the work in the shop or in the field to allow ample time, in consideration of the number and complexity of the drawings in the submittal, for the Owner's Representative to make an orderly review. No extension to complete the work will be granted to the Contractor by reason of his failure in this respect.
- E. The Contractor shall carefully check shop drawings and samples, including those received by them from Subcontractors and material personnel, for accuracy, completeness of required information and conformance with the Contract Documents. Shop drawings found to be inaccurate, incomplete or not in conformance with the Contract Documents shall be corrected and/or appropriately annotated before being submitted to the Owner's Representative for review.
- F. Each submitted shop drawing shall bear the Contractor's stamped and signed certification (i.e., by the Project Manager) that the work has been checked for all related job conditions, for maintenance of architectural conditions, and coordinated with the shop drawings of other trades for interrelated work, as required for the proper and complete performance of the work. No shop drawing submittal will be reviewed without this certification.
- G. While the Contractor shall have access to the Engineer's drawings, neither the Engineer's drawings nor electronic files nor any other reproduced copy of the Engineer's drawings at any scale shall be used by the Contractor to generate any shop drawings. Shop drawings shall be completely drawn at the appropriate scale for any purpose on the project.

- H. Each shop drawing and sample submitted for review shall be accompanied by a letter of transmittal, and shall be identified by the project title, Contractor's name, and a reference to the related part of the Contract Documents.
- I. Shop drawings for manufactured material and equipment shall include model numbers, dimensioned drawings, operating weights, material specifications, operating features and controls wiring diagrams, performance characteristics, service procedures, including clearance requirements for maintenance work, and conformance to specified Codes and standards. Note that in addition to these requirements, other specific submittal data, and forms of data submission, are required by the Contract Documents for particular items of equipment and material.
- J. Shop drawings for Switchboard Rooms, electric closets, and for conduit and similar distribution services shall show by dimension the exact size and location of each element of the system in both the horizontal and vertical plane, as well as relationship to the building structure, architectural construction, equipment, and the work of other Trades. Shop drawings shall clearly show where doors providing access to equipment will be required in finished construction. Pads, foundations, anchorages, supports and attachments to the building structure, where required for the installation of the work shall be shown in layout and detail with sizes, dimensions, materials and methods of construction noted. The work described in any shop drawing submission shall be carefully checked by this Contractor for all clearances, including those required for maintenance, servicing equipment removal, field conditions, maintenance of architectural conditions and proper coordination with all Trades on the job. Each submitted shop drawing shall include a certification by the Contractor that all related job conditions have been checked and that no conflict exists. No shop drawing submission will be reviewed without such certification.
- K. Ensure clean pathways including use of elevators, hoists, cranes / gantries for the delivery of equipment to designated locations. Coordinate all openings required for equipment passage with other trades.
- L. Samples shall be identical in all respects to the material which is to be installed or applied in the execution of the work, and shall be of sufficient size or quantity to permit proper evaluation and review. Manufacturer's descriptive labels and printed application instructions which are normally attached to the material or its packaging shall be furnished with the sample. Samples shall be submitted for review when requested by the Owner's Representative.
- M. Within the agreed upon time period but no later than three weeks after award of the Contract, the Contractor shall submit for the Owner's Representative's review, a list of the manufacturers products and services he proposes to use for the work. .

- N. Within the agreed upon time period but no less than six weeks after award of the Contract, the Contractor shall submit a schedule listing all shop drawings and samples with the projected date that each item will be submitted to the Owner's Representative for review.
- O. Review of drawings and other material submitted shall not be construed as a complete check or constitute a waiver of the requirements of the Contract Documents. This review shall not relieve the Contractor of the responsibility to fit the proposed materials to the spaces provided, and to effect necessary rearrangement or construction of other Work.

1.14 RECORD DRAWINGS

- A. The Contractor shall maintain on a daily basis at the Project site a complete set of "Record Drawings". The "Record Drawings" shall consist of a set of blueline prints and AutoCAD files of the Contractor Coordination Drawings for this Section. The prints shall include the updated AutoCAD files, which shall be periodically electronically updated to show the precise location of all buried or concealed work and equipment, including embedded piping and valves, and all changes and deviations in the Electrical work from that shown on the Contract Documents. This requirement shall not be construed as authorization for the Contractor to make changes in the layout or work without written definite instructions from the Owner's Representative. Prior to commencing work, the Contractor shall obtain from the Owner's Representative a set of AutoCAD Drawings on CD-ROM to be used only to produce the Contractor's Coordination Drawings. The continuously updated coordination drawings shall be used to produce the final "Record Drawings" which shall be delivered to the Owner in AutoCAD electronic format upon Project completion. The Contractor shall give to the Owner's Representative the written release, included as part of this Section in Appendix B, signed by a corporate officer of the Contractor prior to receipt of the Engineer's diskettes.
- B. Dimensions shall clearly and accurately delineate the work as installed; locations shall be suitably identified by at least two dimensions to permanent structures.
- C. Upon completion of the Work, the Contractor shall certify all "Record Drawings" on the front lower right hand corner adjacent to the above marking with a rubber stamp impression or an AutoCAD image that states the Project name, the Contractor's name, the area covered and the date.
- D. Prior to final acceptance of the Work of this Section, the Contractor shall submit properly certified "Record Drawings" to the Owner's Representative for review and shall make changes, corrections, or additions as the Owner's Representative may require to the "Record Drawings". After the Owner's Representative's review, and any required Contractor revisions, the "Record Drawings" shall be delivered to the Owner on CD-ROM in AutoCAD format for the Owner's use.

1.15 SUBSTITUTIONS

- A. Specified products or equipment mean those named on the manufacturer list in the Specifications. All other manufacturers are considered substitutions.
- B. Proposed substitutions for material and equipment required by the Contract Documents shall be submitted to the Owner's Representative for review at the time when the Contractor submits a list of the manufacturers whose products and services he proposes to use for the work. After the expiration of this period, substitutions for material or equipment shall not be proposed or requested in shop drawing and sample submittals, and the Contractor will be required to execute the work in accordance with the provisions of the Contract Documents
- C. Submittals proposing or requesting substitutions shall be expressly identified as such in a letter of transmittal, with the reasons for requesting the substitution stated and a clear table of comparison listing pertinent features of both first named and proposed materials including material of construction, overall length, width, height dimensions, space required for tube replacement or maintenance access, motor type, horsepower, voltage, phase service factor, noise levels and performance data. Review of proposed substitution will not be made until receipt of satisfactory comparison tabulation.
- D. The judgment of the Owner's Representative with respect to the adequacy and acceptability of a proposed substitution shall be final and binding on the Contractor.
- E. Any additional work required by other trades as a result of a substitution shall be covered under this Contract. Submittals for this purpose shall be complete in every respect, shall conform to all the information requirements for shop drawing and sample submittals, and shall include, at no cost, the necessary revisions to other related work required by the Contract Documents
- F. When a substitution is proposed, the Contractor shall be responsible to ensure that the performance and quality of the scheduled or specified equipment is met including all accessories.

1.16 DELIVERY, STORAGE, HANDLING AND PROTECTION

- A. Include all shipping, delivery, hauling, hoisting, shoring, and placement in the building of equipment and materials specified herein. The Contractor shall be responsible for the timely delivery of equipment to the project site as required by the construction schedule. If any item of equipment is received prior to the time it is required, the Contractor shall be responsible for its proper storage and protection until such time as it may be required. The Contractor shall pay for all costs of storage in a bonded warehouse.

- B. If any item of equipment is not delivered to or installed at the Project site in a timely manner as required by the Project construction schedule, the Contractor shall be solely responsible for disassembly, re-assembly, manufacturer's supervision, shoring, general construction modifications, delays, overtime costs, etc. No additional cost or delays shall be incurred by the Owner.
- C. All other trades' equipment, materials and work shall be protected from damage in areas where electrical work is being carried out. All damage shall be corrected in a manner acceptable to the Owner without additional cost to the Owner.
- D. The Contractor shall be responsible for all work, materials and equipment until finally inspected, tested and accepted; protect work against theft, injury or damage; and carefully store material and equipment received on site which is not immediately installed. All the equipment, materials and the work shall be covered and protected during construction to prevent entry of dust, dirt, obstructing material and to prevent damage due to weather, water, spray-on fireproofing, construction debris, etc., in a manner acceptable to the Owner.
- E. All equipment, materials, devices, etc stored off site and delivered to the site must be kept in the manufacturers' original unopened protective packaging with shipping bars, retainers and positioning devices in place until installation. Store all items subject to moisture damage in dry and heated space with factory covering in place.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Equipment and materials furnished shall be new and unused, prior to this installation, first grade commercial quality and shall be essentially the standard cataloged products of a manufacturer regularly engaged in the manufacture of the products. Only those items specifically shown on the Drawings as existing, relocated or Owner furnished shall be reused in this installation. Rebuilt or remanufactured equipment will not be permitted.
- B. Since manufacturing methods vary, reasonable minor variations are expected; however, performance and material requirements specified herein are the minimum standards acceptable. The Owner's Representative retains the sole right to judge the equality of equipment that deviates from the Contract Documents, to reject any substitutions submitted by the Contractor, and to require the specified materials and equipment which conform to the requirements of the Contract Documents be furnished.
- C. Equipment and materials that have defects or damage during transportation, installation, or operation is considered as totally damaged. They shall be replaced

new. The materials and equipment which have minor damage may be repaired if written approval is given by the Owner. If equipment and materials are approved for repairs, they shall be repaired in a manner acceptable to the Owner at no additional cost to the Owner. The Contractor shall be responsible for all costs associated with the repairs, replacement, including but not limited to, all preparations prior to re-testing, extended warranties, re-commissioning of the equipment, etc.

- D. Where no specific make of material or equipment is mentioned, use any product of reputable manufacturer which conforms to requirements of the project, the associated system and other applicable specification sections.

2.2 IDENTIFICATION

- A. All major components of the electrical distribution system and parts of equipment, such as switchboards, panelboards, safety switches, motor controllers, circuit breakers, time clocks, contactors, automatic/manual transfer switches, relays, transformers, pull and junction boxes, control boxes/panels, troughs, etc and similar items shall be identified by name, source of power or circuit origin, load served, voltage, number of phases, current rating. Where equipment or devices, such as transfer switches and relays, are powered from two sources, both normal and emergency shall be identified with the required information.
- B. All major components of the Fire Alarm System, such as Fire Alarm control panels, strobe panels data gathering panels, amplifiers, fan shut down control panels, etc, shall be identified by the designations indicated on the contract drawings.
- C. Equipment shall be identified by means of nameplates fastened to the equipment with brass plate screws. Nameplates for the Normal Power Distribution System shall be black surface, white core laminated Bakelite with engraved letters. Nameplates for the Emergency Power Distribution System and Fire Alarm System shall be Red surface, white core laminated Bakelite with engraved letters.
- D. All nameplates shall be a minimum of 2 in. wide by 4 in. long with engraved white letters 1/4 in. high except for major Fire Alarm System and Electrical Distribution System, such as panelboards, distribution boards, switchboards, pull boxes, transfer switches and motor control centers, uninterruptible power supply system, etc., a minimum of 3 in wide by 6 in long with one-inch-high letters shall be used.
- E. Identify each outlet box, junction box, pull box, cabinet, etc for emergency and fire alarm circuitry by red paint. In addition to the red paint, boxes for fire alarm circuitry shall have the black 1-inch "FA" lettering.
- F. Circuits and pull wires shall have tags attached to them at junction boxes, panelboards, switchboards, switchgears, transfer switches, pull boxes, relays,

support boxes, etc. Tags shall be made of pressure sensitive tape or embossed self-attached ribbon. Feeder or branch circuit numbers and origin and equipment/devices served shall be indicated on the tag. All cables, No. 3 and larger, shall be identified with engraved cable markers indicating the required information at all pull boxes, support boxes and terminal devices.

- G. Nomenclature shall be according to a schedule approved by the Engineer. Nameplates and tag symbol shall correspond to the identification on the contract Drawings and on the Record Drawings.
- H. Cardholders and directory cards shall be provided for circuit identification in panelboards. Cardholder shall be located and permanently attached on the inside of panel board door and shall be plastic frame with clear lexan front. Directory cards shall be typewritten. Circuit descriptions shall include specific floor and unit designations as indicated on floor plans and schedules for all equipment served.
- I. Equipment rated above 600V, shall be provided with a "DANGER – HIGH VOLTAGE – QUALIFIED PERSONNEL ONLY" sign at compartment doors and doors providing access to the equipment.

PART 3 - EXECUTION

3.1 SEISMIC REQUIREMENT:

- A. Seismic restraints for equipment, conduits, cable trays, devices, luminaires, equipment housekeeping pads and equipment supports shall be provided and shall comply with the latest seismic and applicable codes. Refer to the applicable specification sections for other requirements.

3.2 PENETRATIONS:

- A. Avoid, if possible, the penetration of any waterproof membranes such as roofs, machine room floors, basement slabs and walls, and the like. If such a penetration is necessary, perform it prior to the waterproofing and furnish all sleeves or pitch-pockets required. Advise the Owner's Representative and obtain written permission before penetrating any waterproof membrane, even where such penetration is shown on the Drawings.
 - 1. Any sleeves required shall extend 2" above finished floor
- B. If Contractor penetrates any walls or surfaces after they have been waterproofed, he shall restore the waterproof integrity of that surface as directed by the Owner's Representative at his own expense.

- C. Pack space between conduits, sleeves, cable trays and seal unused sleeves in non-fire rated walls with non-combustible materials. Refer to specifications for details and requirements.
- D. Conduit enters the building through a concrete foundation wall below grade level; a watertight entrance seal shall be used. The seal shall be OZ/Gedney.
- E. Make penetrations through floors, walls and any damp-proofed/water-proofed surfaces, damp-proof/waterproof by appropriate means to maintain integrity of system penetrated. Refer to specifications for details and requirements.
- F. Seal around penetrations and between conduits, cable trays, sleeves, etc and seal unused sleeves, in fire rated walls with UL listed fireproofing system to maintain fire rating integrity of penetrated membrane. Refer to specifications for details and requirements.
- G. The Contractor shall be responsible for the timely placing of sleeves for all piping passing through walls, partitions, beams, floors, and roofs, while the same are under construction.

3.3 EXPANSION/DEFLECTION

- A. Equip all cable trays and conduits, including those embedded in concrete, which cross building expansion or control joints, with expansion fittings.
- B. Where conduits are subjected to expansion and movement in any directions or to vibration transmitted by equipment or vehicular traffic, install a combination expansion and deflection fittings.

3.4 SUPPORT

- A. Provide required supports and hangers for conduit and equipment, so that loading will not exceed allowable loadings of structure. Submittal of a bid shall be deemed a representation that such bid has included allowable loadings and has included the costs associated in furnishing required supports.
- B. The design of the supports for conduits, busway and equipment shall be certified and sealed by a Professional Engineer licensed in the State in which the work is to be performed.
- C. Where equipment (transformers, busway, conduit racks, etc.) are supported from structural slabs, the Contractor shall provide all miscellaneous structural members to support the load plus a 250 lb. live load.

- D. The Contractor shall submit Shop Drawings of the riser support system inside vertical shafts to the Owner's Representative for review, including details of how the riser support structure is to be attached to the building structure
- E. Miscellaneous structural support members installed in Electrical Rooms, electric closets, central plants, Mechanical Rooms shall be galvanized steel.
- F. Include supporting frames or racks extending from floor slab to ceiling slab for work indicated as being supported from walls where the walls are incapable of supporting the weight. In particular, provide such frames or racks in electric closets.
- G. Include supporting frames or racks for equipment, intended for vertical surface mounting, which is required in a freestanding position. Supporting frames or racks shall be of standard angle, standard channel or specialty support system steel members. They shall be rigidly bolted or welded together and adequately braced to form a substantial structure. They shall be firmly secured to the floor slab with expansion anchors designed to support the system and the equipment. Racks shall be of ample size to assure a workmanlike arrangement of all equipment mounted on them and shall not impinge code required work space of other equipment, devices, access panel, junction boxes, pull boxes, etc.
- H. Wall mounted equipment may be directly secured to wall by means of steel bolts. Maintain at least 1" air space between equipment and supporting wall. Groups or arrays of equipment may be mounted on adequately sized steel angles, channels, or bars. Prefabricated steel channels providing a high degree of mounting flexibility, such as those manufactured by Kindorf, Glob-Strut and Unistrut, may be used for mounting arrays of equipment.
- I. No equipment, including outlet, pull and junction boxes and fittings, shall depend on electric conduits, raceways, or cables for support, except that threaded hub type fittings having a gross volume not in excess of 100 cubic inches may be supported from heavy wall conduit, where the conduit in turn is securely supported from the structure within five inches of the fitting on two opposite sides.
- J. Nothing shall rest on, or depend for support on, suspended ceiling media (tiles, lath, plaster, as well as splines, runners, bars and the like in the plane of the ceiling). If suspended ceilings are used to support lighting fixtures, they shall be designed to support the weight of the fixtures. Branch circuit conduit up to 3/4" may be permitted to be supported from ceiling hanger rods if the allowable loading of the rods is not exceeded as agreed by the Owner's Representative.
- K. For items, which are shown, as being ceiling mounted at locations where fastening to the building construction element above is not possible, provide suitable auxiliary channel or angle iron bridging, tying to the building structural elements.

3.5 DISSIMILAR METALS

- A. Dissimilar metals shall mean those metals, which are incompatible with one another in the presence of moisture. Where dissimilar metals come in contact, paint the joint both inside and out with appropriate coating so as to exclude moisture from the joint, or provide a suitable insulating barrier separating the metals.
- B. Transitions in raceways, from one metal to a dissimilar metal shall only be made at boxes or other enclosures.

3.6 CUTTING, PATCHING, SLEEVES

- A. The work shall be carefully laid out in advance. Where cutting, channeling, chasing or drilling of floors, walls, partitions, ceilings or other surfaces is necessary for the proper installation, support or anchorage of raceway, outlets or other equipment, the work shall be carefully done and where required, fire rating integrity shall be restored. Any damage to the piping, equipment or defaced finish plaster, woodwork, metalwork, etc. shall be repaired by skilled mechanics of the trades involved at no additional cost to the Owner. Refer to architectural specifications for details and requirements.
- B. The Contractor shall do no cutting, channeling, chasing or drilling of unfinished masonry, tile, floor slab, etc., unless he first obtains permission from the Owner's Representative. If permission is granted, the Contractor shall perform this work in a manner consistent with the Contract Documents.
- C. If holes and/or sleeves are not properly installed and cutting and patching becomes necessary, it shall be done at no additional expense to the Owner. The Contractor shall undertake no cutting or patching without first securing the Owner's Representative's written permission.
- D. Where other Trades are required to do cutting and patching, furnish to the Construction Manager necessary information so that openings for this work can be built into the floors and walls in time. Such cooperation is required to keep cutting of walls and floors to a minimum.
- E. Should Contractor neglect to perform preliminary work, and should cutting be required in order to install equipment, conduits, etc, the expense of this cutting and restoring of surfaces to their original condition shall be borne by this Contractor.

3.7 PAINTING

- A. Equipment furnished under this Section shall have factory-applied finish. If the factory finish is damaged during shipment, storage, installation, etc., it shall be repainted by this Contractor subject to review by the Owner's Representative. Touch-up painting is acceptable only for minor finish damage.

- B. Provide a heavy field coat of black asphaltum paint on all steel conduits, cradles, vibration isolating mounts, and the like, that will be encased or partially encased in building construction, set in cement or fill, before items are built into the general construction.
- C. Where conduits, mounting channels, outlet, junction, or pull boxes are mounted on a painted surface, or a surface to be painted they shall be painted, by this contractor, to match the surface.

3.8 CLEANING UP

- A. Contractor shall take care to avoid accumulation of debris, boxes, crates, etc., resulting from the installation of the work. Contractor shall remove from the premises each day all debris, boxes, etc., and keep the premises clean, subject to the Owner's instructions, which shall be promptly carried out.
- B. Contractor shall clean up all luminaires and equipment at the completion of the project.
- C. All switchboards, switchgear, busway, panelboards, wireways, transformers, transfer switches, trench ducts, cabinets, enclosures, etc. shall be thoroughly vacuumed clean prior to energizing equipment and at the completion of the project. Equipment shall be opened for observation by the Owner's Representative as required.

3.9 EQUIPMENT PADS AND MOUNTING

- A. Provide fully dimensioned pad layouts based on data from manufacturer of electrical equipment. Shop Drawings shall be used for dimensional guidance in sizing pads, anchor bolts, locations, etc.
- B. Pads shall be provided for floor-mounted equipment, equipment mounted on legs and/or support stands and they shall conform to the shape of the piece of equipment it serves with a minimum 3 in. margin around the equipment and supports. Pads shall be a minimum of 4 in. high and made of a minimum 28-day, 3000 psi concrete reinforced with 6"x6", 6/6 gauge welded wire mesh. Top and sides of the pad shall be troweled to smooth finishes, equal to those of the floors, with all corners bullnosed to 3 / 4" radius.
- C. Pads shall be dowelled into structural slab with #4 rebars at each corner embedded 3" and grouted with non-shrink grout.
- D. Furnish and install galvanized anchor bolts for all equipment placed on concrete equipment pads, inertia blocks, or on concrete slabs. Bolts shall be the size and number recommended by the manufacturer of the equipment and as required for seismic restraint. Anchor bolts shall be anchored to the structural floor slab and

shall be located by means of suitable templates. When equipment is placed on vibration isolators, the equipment shall be secured to the isolator and the isolator secured to the floor, pad, or supported as recommended by the vibration isolation manufacturer.

- E. Equipment pads for switchboards and transformers shall have level mounting channels embedded in the concrete as specified in the applicable sections. Where equipment is mounted on gypsum board partitions, the mounting screws shall pass through the gypsum board and be securely attached to the partition studs or framework.

3.10 EQUIPMENT NOISE AND VIBRATION

- A. Equipment and systems, as defined herein, shall be quiet and free of apparent vibration while in operation.
- B. Vibration shall not be apparent to the senses in occupied areas of the building. Both the balancing of rotating machinery and the installation of vibration isolators are required.
- C. Any additional precautions deemed necessary to provide a quiet installation shall be done as part of the Work of this Section, subject to review by the Owner's Representative and without additional cost to the Owner. After the systems are in operation, it shall be the responsibility of the Contractor to make any changes to equipment or Work.

3.11 FINAL ACCEPTANCE TESTS

- A. The entire electrical installation shall be pre-tested, inspected, thoroughly cleaned, and damaged finishes touched up after final completion prior to final acceptance testing being performed. Not less than 30 days prior to the final acceptance testing, furnish the pre-test results and a test plan to the Owner for review, outlining all aspects of the testing, including tests to be performed and the expected results.
- B. Provide complete documentation of all component and system tests prior to Owner acceptance and turnover of components or systems. In addition, the Owner reserves the right to review all test objectives, test plans and test cases, and witness all preoperational tests. Provide the Owner with a comprehensive schedule detailing the preparation of testing documentation and the conduct of all component or system tests.
- C. Perform the following field test in the presence of the Owner's Representative to demonstrate the reliability of the electrical installation. Give the Owner's Representative a minimum two-week advance notice of such tests.

- D. Operate all electrical systems and equipment for a period of 24 hours, unless in the opinion of the Owner's Representative, a different test period is required, to prove the operation and performance of a system and its equipment.
- E. Should the foregoing test reveal any defects, promptly correct such defects and re-run the tests until the entire installation conforms to the requirements of these Specifications and the Drawings.
- F. Tests requiring certified reports and those requiring factory or field inspection shall be conducted and reported to the Owner's Representative in conformance with standards specified in the applicable sections.
- G. Thermo-graphic Inspection
 - 1. In addition to the tests outlined above, after completion of the electrical system and prior to occupancy, the following equipment and devices, as a minimum, shall be thermo-graphically inspected.
 - a. Feeder splices and connections.
 - b. Switchboards.
 - c. Transformers.
 - d. Panelboards.
 - e. Automatic transfer switch and emergency power system connections.
 - f. All 600 volt (nominal) cable connections rated 100 amperes (#3 AWG) or greater.
 - g. Other equipment as shown on the Drawings
 - 2. The inspection shall be made by an independent inspection company. The inspection shall be made with all equipment, motors, lighting fixtures, and miscellaneous loads operating and with equipment covers removed.
 - 3. Inspection reports complete with color photographs of the infrared scan and control photographs indicating the ambient temperature and any hot spots of each item inspected shall be submitted to the Owner's Representative for review. Any equipment, connections or devices indicated to be operating improperly performing equipment shall be replaced or repaired by the Contractor at no cost to the Owner.
- H. The date for the final performance acceptance testing shall comply with the Project construction schedule and shall be sufficiently in advance of the Contract completion date to permit the execution of the testing by the Contractor prior to occupancy and the close-out of the Contract. Any adjustments and/or alterations which the final acceptance tests indicate as necessary for the proper and

satisfactory functioning of all equipment and systems shall be completed prior to the close-out of the Contract. Re-tests shall not relieve the Contractor of completion date responsibility.

- I. The Contractor shall provide a detailed schedule of completion indicating when each system is to be completed and outlining when tests will be performed. Completion schedule shall be submitted to the Owner for review at the time requested by the Construction Manager after the notice to proceed has been given by the Owner. This schedule shall be updated periodically by the Contractor as the Project progresses. Each update shall be submitted to the Owner for review.
- J. Contractors' tests shall be scheduled and documented in accordance with the commissioning requirements. Refer to Section 01 91 00, Commissioning, for further details.

3.12 DEMONSTRATION AND OPERATION INSTRUCTIONS

- A. After completion of all testing, and prior to placing equipment or systems in operation, demonstrate the features and operation of the equipment or systems to the Owner's operational and maintenance personnel so that they are familiarized with the equipment and systems, in particularly the following equipment and systems:
 1. Switchboards and panelboards.
 2. Transformers.
 3. Power monitoring system
 4. Emergency power system
 5. Lighting Control system
 6. Fire alarm and smoke detection systems.
 7. Automatic transfer switches
 8. Other equipment and control systems shown on the Drawings.
- B. Provide the necessary accessories, test equipment, and personnel, for each demonstration.
- C. Complete all arrangements for the demonstrations through the Owner's Representative.
- D. Upon the completion of each demonstration or instructional session, obtain "sign-off" from the Owner. The "sign-off" shall state that the demonstration or

instructions for use were provided, that they were complete and were given to the designated personnel.

- E. The Contractor shall provide the services of a factory trained specialist to supervise the commissioning, startup, and operation of all equipment specified herein and to instruct the Owner's operators during an operating instruction period at or near the Project site. The operating instruction period shall be defined as straight time working hours and shall not include nights, weekends, or travel time to and/or from the Project. See individual sections of these specifications for additional instructions by manufacturer-trained specialists.
- F. The Owner's Representative shall be notified in writing at least two (2) weeks before each operating instruction period begins. The Contractor shall commence no instruction period until the Owner's Representative has issued his written acceptance of the starting time.

3.13 OPERATION AND MAINTENANCE MANUALS

- A. The Contractor shall provide operating instructions and maintenance data books for all equipment and materials specified in this Division.
- B. Submit six (6) copies of operation and maintenance manuals for review at least ten (10) weeks before Final Review of the Project. Assemble all data in a completely indexed volume or volumes in three-ring binders and identify the size, model, and features indicated for each item. The binders shall have the Project Name and Logo printed on the outside of the binders. These manuals shall be submitted and subjected to the same review process as detailed for shop drawings and samples but shall be returned as "REVIEWED." Submit four (4) copies of the "REVIEWED" operation and maintenance books to the Construction Manager upon Project completion.
- C. Operation and Maintenance manuals shall include complete cleaning, and servicing data compiled in clearly and easily understandable form. Data shall show serial numbers and model numbers of each piece or equipment, complete lists of replacement parts (including part numbers), motor ratings, and actual loads.
- D. Include the following information where applicable:
 - 1. Identifying name and mark number.
 - 2. Locations of major equipment (where several similar items are used, provide a list).
 - 3. Complete nameplate data.
 - 4. "Reviewed" submittals as returned to this Contractor.

5. Parts lists.
6. Performance curves and data.
7. Wiring diagrams.
8. Lubrication charts.
9. Manufacturers' recommended operation and maintenance instructions with all non-applicable information deleted.
10. List of spare parts recommended for normal service requirements.
11. Assembly and disassembly instructions with exploded view Drawings where available.
12. Trouble shooting diagnostic instructions where available.

3.14 FINAL REVIEW

- A. At a time designated, the entire installation shall be reviewed for compliance with the Contract Drawings and Specifications. The Contractor shall be available at all times during this Review.
- B. The Contractor shall demonstrate prior to the Final Review that all systems and all equipment have been properly adjusted and are in compliance with the requirements of the Contract Documents. After the demonstration tests are completed satisfactorily, but prior to the Final Review field visit, the Contractor shall submit to the Owner's Representative a written certification that:
 1. Attests to Contract Document compliance for this Project, and Certifies that the equipment and materials installed in this Project contain no asbestos or PCB.
- C. Certificates and Documents required herein shall be in order and presented to the Owner's Representative at least two (2) weeks prior to the Final Review.
- D. After the Final Review, any changes or corrections noted as necessary for the Work to comply with these Specifications and the Drawings shall be accomplished without delay in order to secure final acceptance of the Work.

END OF SECTION

SECTION 26 05 13

MEDIUM-VOLTAGE CABLES

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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 cables and related cable splices, terminations, and accessories for medium-voltage (2001 to 35,000 V) electrical distribution systems.

1.3 DEFINITIONS

- A. Jacket: A continuous nonmetallic outer covering for conductors or cables.
- B. NETA ATS: Acceptance Testing Specification.
- C. Sheath: A continuous metallic covering for conductors or cables.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of cable. Include splices and terminations for cables and cable accessories.
- B. Samples: 16-inch (400-mm) lengths for each type of cable specified.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Indicate location of each cable, splice, and termination.
- B. Qualification Data: For testing agency.
- C. Material Certificates: For each type of cable and accessory.
- D. Design Data: Cable pulling calculations, including conduit size and fill percentage, pulling tensions, cable sidewall pressure, jam probability, voltage drop, and ground wire sizing for each cable.
- E. Source quality-control reports.
- F. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.
- B. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

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. Comply with IEEE C2 and NFPA 70.
- C. Source Limitations: Obtain cables and accessories from single source from single manufacturer.

2.2 CABLES

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Cables
 - a. Okonite Company (The)
 - b. Kerite
 - c. Southwire
 - d. Houston Wire and Cable
 - 2. Cable Splicing and Terminating Products and Accessories
 - a. Cooper Power Systems, Inc.
 - b. Elastimold.
 - c. 3M; Electrical Markets Division.
 - d. Tyco Electronics; Raychem Products.
- B. Cable Type: Type MV 105.
- C. Conductor Insulation: Ethylene-propylene rubber.
 - 1. Voltage Rating: 15 kV.
 - 2. Insulation Thickness: 133 percent insulation level.
- D. Conductor: Copper.
- E. Comply with UL 1072, AEIC CS8, ICEA S-93-639/NEMA WC 74, and ICEA S-97-682.
- F. Conductor Stranding: Compact round, concentric lay, Class B.
- G. Strand Filling: Conductor interstices are filled with impermeable compound.
- H. Lead Content: Less than 300 parts per million.
- I. Shielding: Copper tape, helically applied over semiconducting insulation shield.
- J. Cable Jacket: Sunlight-resistant PVC.

2.3 CONNECTORS

- A. Comply with ANSI C119.4 for connectors between aluminum conductors or for connections between aluminum to copper conductors.
- B. Copper-Conductor Connectors: Aluminum barrel crimped connectors.

2.4 SOLID TERMINATIONS

- A. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class shall be equivalent to that of cable. Include shield ground strap for shielded cable terminations.
 - 1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone-rubber, insulator modules; shield ground strap; and compression-type connector.

2.5 SEPARABLE INSULATED CONNECTORS

- A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.
- B. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.
- C. Dead-Break Cable Terminators: Elbow-type unit with 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.
- D. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.
- E. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.6 SPLICE KITS

- A. Description: For connecting medium voltage cables; type as recommended by cable or splicing kit manufacturer for the application.
- B. Standard: Comply with IEEE 404.
- C. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, materials, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.
 - 1. Combination tape and cold-shrink-rubber sleeve kit with re-jacketing by cast-epoxy-resin encasement or other waterproof, abrasion-resistant material.
 - 2. Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket.
 - 3. Premolded, cold-shrink-rubber, in-line splicing kit.
 - 4. Premolded, EPDM splicing body kit with cable joint sealed by interference fit of mating parts and cable.
 - 5. Separable multiway splice system with all components for the required splice configuration.

2.7 MEDIUM-VOLTAGE TAPES

- A. Description: Electrical grade, insulating tape rated for medium voltage application.
- B. Ethylene/propylene rubber-based, 30-mil (0.76-mm) splicing tape, rated for 130 deg C operation. Minimum 3/4 inch (20 mm) wide.
- C. Silicone rubber-based, 12-mil (0.30-mm) self-fusing tape, rated for 130 deg C operation. Minimum 1-1/2 inches (38 mm) wide.
- D. Insulating-putty, 125-mil (3.175-mm) elastic filler tape. Minimum 1-1/2 inches (38 mm) wide.

2.8 SOURCE QUALITY CONTROL

- A. Test and inspect cables according to ICEA S-97-682 before shipping.

- B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig (35 kPa).

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install cables according to IEEE 576.
- B. Proof conduits prior to conductor installation by passing a wire brush mandrel and then a rubber duct swab through the conduit. Separate the wire brush and the rubber swab by 48 to 72 inches (1200 to 1800 mm) on the pull rope.
 - 1. Wire Brush Mandrel: Consists of a length of brush approximately the size of the conduit inner diameter with stiff steel bristles and an eye on each end for attaching the pull ropes. If an obstruction is felt, pull the brush back and forth repeatedly to break up the obstruction.
 - 2. Rubber Duct Swab: Consists of a series of rubber discs approximately the size of the conduit inner diameter on a length of steel cable with an eye on each end for attaching the pull ropes. Pull the rubber duct swab through the duct to extract loose debris from the duct.
- C. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
 - 1. Where necessary, use manufacturer-approved pulling compound or lubricant that does not deteriorate conductor or insulation.
 - 2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips, that do not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
 - 3. Use pull-in guides, cable feeders, and draw-in protectors as required to protect cables during installation.
 - 4. Do not pull cables with ends unsealed. Seal cable ends with rubber tape.
- D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

- E. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."
- F. Install direct-buried cables on leveled and tamped bed of 3-inch- (75-mm-) thick, clean sand. Separate cables crossing other cables or piping by a minimum of 2 inches (50 mm) of tamped earth, plus an additional 2 inches (50 mm) of sand. Install permanent markers at ends of cable runs, changes in direction, and buried splices.
- G. Install "buried-cable" warning tape 12 inches (305 mm) above cables.
- H. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit; support cables at intervals adequate to prevent sag.
- I. Install sufficient cable length to remove cable ends under pulling grips. Remove length of conductor damaged during pulling.
- J. Install cable splices at pull points and elsewhere as indicated; use standard kits. Use dead-front separable watertight connectors in manholes and other locations subject to water infiltration.
- K. Install terminations at ends of conductors, and seal multiconductor cable ends with standard kits.
- L. Install separable insulated-connector components as follows:
 - 1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
 - 2. Portable Feed-Through Accessory: At each terminal junction, with one on each terminal.
 - 3. Standoff Insulator: At each terminal junction, with one on each terminal.
- M. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:
 - 1. Clean cable sheath.

2. Wrap metallic cable components with 10-mil (250-micrometer) pipe-wrapping tape.
 3. Smooth surface contours with electrical insulation putty.
 4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
 5. Band arc-proofing tape with two layers of 1-inch- (25-mm-) wide half-lapped, adhesive, glass-cloth tape at each end of the arc-proof tape.
- N. Seal around cables passing through fire-rated elements according to Section 078413 "Penetration Firestopping."
- O. Install fault indicators on each phase where indicated.
- P. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.
- Q. Ground shields of shielded cable at one point only. Maintain shield continuity and connections to metal connection hardware at all connection points.
- R. Identify cables according to Section 260553 "Identification for Electrical Systems." Identify phase and circuit number of each conductor at each splice, termination, pull point, and junction box. Arrange identification so that it is unnecessary to move the cable or conductor to read the identification.

3.2 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
 2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
 3. Perform direct-current High Potential test of each new conductor according to NETA ATS, Ch. 7.3.3. Do not exceed cable manufacturer's recommended maximum test voltage.

4. Perform Partial Discharge test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.
 5. Perform Dissipation Factor test of each new conductor according to NETA ATS, Ch. 7.3.3 and to test equipment manufacturer's recommendations.
- B. Medium-voltage cables will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION

SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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. Copper building wire rated 600 V or less.
- 2. Metal-clad cable, Type MC, rated 600 V or less.
- 3. Connectors, splices, and terminations rated 600 V and less.

B. Related Requirements:

- 1. Section 260513 "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 601 to 35,000 V.
- 2. Section 260523 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2, and 3 control cables.

1.3 DEFINITIONS

- A. RoHS: Restriction of Hazardous Substances.

- B. VFC: Variable-frequency controller.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Product Schedule: Indicate type, use, location, and termination locations.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA.
 - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

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. Belden Inc.
 - 2. Encore Wire Corporation.
 - 3. General Cable Technologies Corporation.
 - 4. Okonite Company (The).

5. 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. RoHS compliant.
3. 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. AFC Cable Systems; a part of Atkore International.
2. Belden Inc.
3. Encore Wire Corporation.
4. General Cable Technologies Corporation.
5. Okonite Company (The).
6. 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. Comply with UL 1569.
3. RoHS compliant.
4. 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 and multi-circuit with color-coded conductors.

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, where indicated on drawings.

2.3 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. AFC Cable Systems; a part of Atkore International.
 3. Hubbell Power Systems, Inc.
 4. Ideal Industries, Inc.
 5. O-Z/Gedney; a brand of Emerson Industrial Automation.
 6. Thomas & Betts Corporation; A Member of the ABB Group.
- 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.
 2. Type: Two hole with long barrels.
 3. Termination: Crimp.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- C. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type XHHW-2, single conductors in raceway.
- B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.

- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN/THWN-2, single conductors in raceway.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.
- E. Exposed Branch Circuits, Including in Crawlspace: Type THHN/THWN-2, single conductors in raceway.
- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Metal-clad cable, Type MC.
- G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.
- H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- I. VFC Output Circuits:
 - 1. For VFC output circuit lengths up to 50 feet: Type XHHW-2 in metal conduit.
 - 2. For VFC output circuit lengths 50 - 100 feet: Type TC-ER cable with braided or dual tape shield.
 - 3. For VFC output circuit lengths greater than 100 feet: Type TC-ER cable with dual tape shield.

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 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 inches (150 mm) of slack.
- D. Comply with requirements in Section 283111 "Digital, Addressable Fire-Alarm System" for connecting, terminating, and identifying wires and cables.

3.5 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.

3.6 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."

3.7 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."

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.

- 1. After installing conductors and cables and before electrical circuitry has been energized, test the following conductors for compliance with requirements:
 - a. All service entrance conductors.
 - b. All feeder conductors.
 - c. All branch circuit conductors 100A and greater.
- 2. Perform each of the following visual and electrical tests:
 - a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
 - b. Test bolted connections for high resistance using one of the following:
 - 1) A low-resistance ohmmeter.
 - 2) Calibrated torque wrench.
 - 3) Thermographic survey.
 - c. Inspect compression-applied connectors for correct cable match and indentation.
 - d. Inspect for correct identification.
 - e. Inspect cable jacket and condition.
 - f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.

- g. Continuity test on each conductor and cable.
 - h. Uniform resistance of parallel conductors.
- 3. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.
 - a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - b. 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.
- 4. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.
- C. Cables will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports to record the following:
 - 1. Procedures used.
 - 2. Results that comply with requirements.
 - 3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION

SECTION 26 05 23

CONTROL-VOLTAGE ELECTRICAL POWER CABLES

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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. RS-485 cabling.
 - 2. Low-voltage control cabling.
 - 3. Control-circuit conductors.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
- C. 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.
- D. RCDD: Registered Communications Distribution Designer.

1.4 ACTION SUBMITTALS

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

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency, RCDD, layout technician, installation supervisor, and field inspector.
- B. Source quality-control reports.
- C. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.
 - 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

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. 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.
 - 1. Flame Travel Distance: 60 inches (1520 mm) or less.
 - 2. Peak Optical Smoke Density: 0.5 or less.
 - 3. Average Optical Smoke Density: 0.15 or less.

- C. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.
- D. 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.
- E. RoHS compliant.

2.2 RS-485 CABLE

- A. Standard Cable: NFPA 70, Type CMG.
 - 1. Paired, [one pair] [two pairs], twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - 2. PVC insulation.
 - 3. Unshielded.
 - 4. PVC jacket.
 - 5. Flame Resistance: Comply with UL 1685.
- B. Plenum-Rated Cable: NFPA 70, Type CMP.
 - 1. Paired, [one pair] [two pairs], No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - 2. Fluorinated ethylene propylene insulation.
 - 3. Unshielded.
 - 4. Fluorinated ethylene propylene jacket.
 - 5. Flame Resistance: NFPA 262.

2.3 LOW-VOLTAGE CONTROL CABLE

- A. Paired Cable: NFPA 70, Type CMG.

1. One or Multi-pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1685.

B. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. One or Multi-pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

2.4 CONTROL-CIRCUIT CONDUCTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Encore Wire Corporation.
 2. General Cable; General Cable Corporation.
 3. Service Wire Co.
 4. Southwire Company.
- B. Class 1 Control Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.
- C. Class 2 Control Circuits: Stranded copper, power-limited cable, concealed in building finishes or power-limited tray cable, in cable tray.

- D. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type THHN/THWN-2, complying with UL 83 in raceway.

2.5 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test twisted pair cables according to TIA-568-C.2.
- C. Cable will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Test cables on receipt at Project site.
 - 1. Test each pair of twisted pair cable for open and short circuits.

3.2 INSTALLATION OF RACEWAYS AND BOXES

- A. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or modified in this Section.
 - 1. Outlet boxes for cables shall be no smaller than 4 inches (102 mm) square by 2-1/8 inches (53 mm) deep with extension ring sized to bring edge of ring to within 1/8 inch (3.1 mm) of the finished wall surface.
 - 2. Flexible metal conduit shall not be used.
- B. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.
- C. Install manufactured conduit sweeps and long-radius elbows if possible.
- D. Raceway Installation in Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed, or in the corner of the room if multiple sheets of plywood are installed around perimeter walls of the room.
 2. Install cable trays to route cables if conduits cannot be located in these positions.
 3. Secure conduits to backboard if entering the room from overhead.
 4. Extend conduits 3 inches (75 mm) above finished floor.
 5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
- E. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Comply with NECA 1.
- B. 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 between termination, tap, or junction points.
 5. Cables serving a common system may be grouped in a common raceway. Install network cabling and control wiring and 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 (760 mm) and not more than 6 inches (150 mm) 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.
 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. Do not bend 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.
 15. Ground wire shall be copper, and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.
- C. Installation of Control-Circuit Conductors:
1. Install wiring in raceways.
 2. Use insulated spade lugs for wire and cable connection to screw terminals.
 3. Comply with requirements specified in Section 26 05 33 "Raceways and Boxes for Electrical Systems."
- D. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-D recommendations for separating unshielded copper voice and data communications cable from potential EMI sources including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
 - b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 12 inches (305 mm).
 - c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 24 inches (600 mm).
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
 - b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
 - c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 12 inches (305 mm).
4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment or Circuit Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 3 inches (75 mm).
 - c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inches (1200 mm).

6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.4 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits; No 14 AWG.
2. Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm, and signal circuits; No 12 AWG.

3.5 FIRESTOPPING

- A. Comply with requirements in Section 07 84 13 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.6 GROUNDING

- A. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.
- B. For low-voltage control wiring and cabling, comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.7 IDENTIFICATION

- A. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."
- B. Identify data and communications system components, wiring, and cabling according to TIA-606-B; label printers shall use label stocks, laminating adhesives, and inks complying with UL 969.
- C. Identify each wire on each end and at each terminal with a number-coded identification tag. Each wire shall have a unique tag.

3.8 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:
 - 1. Visually inspect cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
 - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 3. Test cabling for direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination, but not after cross-connection.
 - a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in its "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in its "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
- D. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
- E. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION

SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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 grounding and bonding systems and equipment.
- B. Section includes grounding and bonding systems and equipment, plus the following special applications:
 - 1. Underground distribution grounding.
 - 2. Ground bonding common with lightning protection system.
 - 3. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:
 - 1. Test wells.
 - 2. Ground rods.
 - 3. Ground rings.
 - 4. Grounding arrangements and connections for separately derived systems.
- B. Qualification Data: For testing agency and testing agency's field supervisor.
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:
 - a. Plans showing as-built, dimensioned locations of system described in "Field Quality Control" Article, including the following:
 - 1) Test wells.
 - 2) Ground rods.
 - 3) Ground rings.
 - 4) Grounding arrangements and connections for separately derived systems.
 - b. Instructions for periodic testing and inspection of grounding features at test wells, ground rings, grounding connections for separately derived systems based on NFPA 70B.

- 1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
- 2) Include recommended testing intervals.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Certified by NETA.

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. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Advanced Lightning Technology, Ltd.
 2. ERICO; a brand of nVent.
 3. Harger Lightning & Grounding.
 4. Hubbell Incorporated (Construction and Energy Group).
 5. ILSCO.
 6. O-Z/Gedney; a brand of Emerson Industrial Automation.
 7. Robbins Lightning, Inc.
 8. Thomas & Betts Corporation; A Member of the ABB Group.

2.3 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B3.
 - 2. Stranded Conductors: ASTM B8.
 - 3. Tinned Conductors: ASTM B33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
 - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

- D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.
- E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.
- F. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.
- G. Conduit Hubs: Mechanical type, terminal with threaded hub.
- H. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.
- I. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.
- J. Lay-in Lug Connector: Mechanical type, [copper rated for direct burial terminal with set screw.
- K. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.
- L. Signal Reference Grid Clamp: Mechanical type, stamped-steel terminal with hex head screw.
- M. Straps: Solid copper, copper lugs. Rated for 600 A.
- N. Tower Ground Clamps: Mechanical type, copper or copper alloy, terminal one-piece clamp.
- O. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.
- P. Water Pipe Clamps:
 - 1. Mechanical type, two pieces with zinc-plated bolts.
 - a. Material: Tin-plated aluminum.
 - b. Listed for direct burial.
 - 2. U-bolt type with malleable-iron clamp and copper ground connector.

2.5 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet (19 mm by 3 m).
- B. Ground Plates: 1/4 inch (6 mm) thick, hot-dip galvanized.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.
 - 1. Bury at least 30 inches (750 mm) below grade.
 - 2. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.
- C. Grounding Conductors: Green-colored insulation with continuous yellow stripe.
- D. Isolated Grounding Conductors: Green-colored insulation with more than one continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- E. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) 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.
- F. 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.

3.2 GROUNDING AT THE SERVICE

- A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

- A. Generator: Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.
- C. 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 No. 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 according to written instructions by manufacturer of splicing and termination kits.

- D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the 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 No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches (150 mm) from the foundation.

3.5 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all 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. 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 a 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 an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.
- F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.
- G. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a 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 No. 8 AWG.
 - 2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
 - 3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.6 FENCE GROUNDING

- A. Fence Grounding: Install at maximum intervals of [1500 feet (450 m)] <Insert a lesser distance if grounding resistance is high> except as follows:
 - 1. Fences within 100 Feet (30 m) of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of [750 feet (225 m)] <Insert a lesser distance if grounding resistance is high>.
 - a. Gates and Other Fence Openings: Ground fence on each side of opening.
 - 1) Bond metal gates to gate posts.

- 2) Bond across openings, with and without gates, except at openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches (460 mm) below finished grade.
- B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet (45 m) on each side of crossing.
- C. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2 unless otherwise indicated.
- D. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches (150 mm) below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.
- E. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.
- F. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

3.7 INSTALLATION

- A. Grounding Conductors: 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.
 - B. 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.
 - C. Ground Rods: Drive rods until tops are 2 inches (50 mm) 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 all below-grade connections.
 3. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 26 05 43 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches (300 mm) deep, with cover.
1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- E. 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 any 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 a disconnect-type connection is required, use a bolted clamp.
- F. 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 a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a 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 a bolted connector.

3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- G. 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.
- H. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.
- I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of the building.
 1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
 2. Bury ground ring not less than 24 inches (600 mm) from building's foundation.
- J. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 feet (6.0 m) long. If reinforcing is in multiple pieces, connect together by the usual steel tie wires or exothermic welding to create the required length.
- K. 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.
 1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
 2. Make connections with clean, bare metal at points of contact.
 3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
 4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.

5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.8 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 tests and inspections.
- D. 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 a calibrated torque wrench according to manufacturer's written instructions.
 3. Test completed grounding system at each location where a 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 any conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any 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 according to IEEE 81.
 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 the record of tests and observations. Include the 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.

- E. Grounding system will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.
- G. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 - 2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
 - 3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
 - 4. Substations and Pad-Mounted Equipment: 5 ohms.
 - 5. Manhole Grounds: 10 ohms.
- H. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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 26 05 48.16 "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 01 40 00 "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.
 3. Response Modification Factor: R=3.
- 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- (10-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c. in at least one surface.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Atkore Unistrut / Power Strut
 - b. ABB Thomas & Betts
 - c. Eaton B-Line
 - d. nVent Caddy
 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.
 9. Corrosive applications and installation of PVC Coated Conduit Systems shall be 316 Stainless Steel Channel by approved manufacturer. Dissimilar metals shall not be allowed in accordance with NEMA - UL Standards.

- B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- C. 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.
- D. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.
- E. 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) B-line, an Eaton business.
 - 2) Hilti, Inc.
 - 3) ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - 4) 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 (Grade A325M).
6. Toggle Bolts: All-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 05 50 00 "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.
- B. Comply with requirements in Section 07 84 13 "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 26 05 33 "Raceways and Boxes for Electrical Systems."
- D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where its Table 1 lists maximum spacings that are less than those stated in NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted 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 two-bolt conduit clamps.
- F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) 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, IMC and RMC 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 (90 kg).
- 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 (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
 6. To Steel: 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.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Section 05 50 00 "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

- B. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 03 30 00 "Cast-in-Place Concrete."
- C. Anchor equipment to concrete base as follows:
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

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 minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Touchup: Comply with requirements in Section 09 91 13 "Exterior Painting" and Section 09 91 23 "Interior Painting" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION

SECTION 26 05 33

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

(Part of Work of Section 260001 – ELECTRICAL, TRADE BID REQUIRED)

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.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing
- B. GRC: Galvanized rigid steel conduit.
- C. 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. Sustainable Design Submittals:
 - 1. Product Data: For solvents and adhesives, indicating VOC content.

C. Shop Drawings:

1. For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

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. 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. Atkore AFC Cable Systems
 - b. Atkore Allied Tube & Conduit
 - c. Atkore Allied Calbond
 - d. Atkore Calbrite
 - e. ABB Thomas & Betts Corporation
 - f. Nucor Republic Conduit
 - g. Western Tube and Conduit Corporation
 - h. Wheatland Tube Company
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. IMC: Comply with ANSI C80.6 and UL 1242.
5. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
 - a. Comply with NEMA RN 1.
 - b. Comply with UL 6
 - c. Comply with ANSI C80.1
 - d. Comply with ETL PVC-001
 - e. Coating Thickness: 0.040 inch (1 mm), minimum.
6. EMT: Comply with ANSI C80.3 and UL 797.

7. FMC: Comply with UL 1; zinc-coated steel.
8. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
9. Stainless Steel Rigid, IMC & EMT Conduit Comply with UL514B, UL6A, ANSI C80.

B. Metal Fittings:

1. Manufacturers: Obtain fittings and accessories manufacturer as the conduits.
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. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
6. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Setscrew or compression.
7. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
8. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

- C. Joint Compound for IMC and GRC: 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. Eaton B-line,
2. nVent Hoffmann;
3. NIEDAX MonoSystems, Inc.
4. Schneider Square D

- B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 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.
- E. Finish: Manufacturer's standard enamel finish.

2.3 SURFACE RACEWAYS

- A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell Incorporated; Wiring Device-Kellems
 - b. Legrand / Wiremold
 - c. NIDAX Inc. MonoSystems, Inc.
 - d. Panduit Corp.

2.4 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Atkore ACS / Unifab
 - 2. ABB Thomas & Betts Steel City
 - 3. Eaton Crouse-Hinds
 - 4. Hubbell Inc. Wiring Device Kellems
 - 5. Hubbell RACO
 - 6. Legrand / Wiremold
- 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, ferrous alloy, Type FD, with gasketed cover.
- E. Metal Floor Boxes:
 - 1. Material: Cast metal.
 - 2. Type: Fully adjustable.
 - 3. Shape: Rectangular.
 - 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- F. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.
- G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.
- I. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- J. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep).
- K. Gangable boxes are not allowed.
- L. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 and Type 4X Stainless Steel 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.
- M. Cabinets:
 - 1. NEMA 250, Type 1 and Type 4X Stainless Steel galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Metal barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Indoors: Apply raceway products as specified below unless otherwise indicated:
 - 1. Low-Voltage, Exposed, Not Subject to Physical Damage: EMT.
 - 2. Low Voltage, Exposed and Subject to Physical Damage: GRC.
 - 3. Feeders concealed in Ceilings and Interior Walls and Partitions: EMT
 - 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 - 5. Damp or Wet Locations: GRC with non-corrosive fittings and GRC elbows..

6. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 3R in damp or wet locations.
- B. Outdoors: Apply raceway products as specified below unless otherwise indicated:
1. Exposed Conduit: GRC.
 2. Concealed Conduit, Aboveground: GRC
 3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 4. Boxes and Enclosures: NEMA 250, Type 4.
- C. Minimum Raceway Size: 3/4-inch (21-mm) trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
 3. EMT: Use setscrew, steel fittings. Comply with NEMA FB 2.10.
 4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. Install all control wiring in conduit.

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 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 (150 mm) 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. Arrange stub-ups so curved portions of bends are not visible above finished slab.

- H. 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 (300 mm) of changes in direction.
- I. 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.
- J. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- K. Support conduit within 12 inches (300 mm) of enclosures to which attached.
- L. Raceways Embedded in Slabs: Not permitted.
- M. Stub-Ups to Above Recessed Ceilings:
 - 1. Use EMT, IMC, or RMC for raceways.
 - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- N. 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.
- O. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.
- P. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
- Q. 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 (35mm) trade size and insulated throat metal bushings on 1-1/2-inch (41-mm) trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
- R. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- S. 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.
- T. Cut conduit perpendicular to the length. For conduits 2-inch (53-mm) trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- U. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300

mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

V. Surface Raceways:

1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

W. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

X. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Conduit extending from interior to exterior of building.
4. Conduit extending into pressurized duct and equipment.
5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
6. Where otherwise required by NFPA 70.

Y. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

Z. Expansion-Joint Fittings:

1. Install in each run of aboveground RMC conduit that is located where environmental temperature change may exceed 100 deg F (55 deg C) and that has straight-run length that exceeds 100 feet (30 m).
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 (70 deg C) temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) 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 (0.06 mm per meter of length of straight run per deg C) 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 (0.0115 mm per meter of length of straight run per deg C) 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.
- AA. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches (1830 mm) 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 in damp or wet locations not subject to severe physical damage.
- BB. 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.
- CC. 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.
- DD. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- EE. Locate boxes so that cover or plate will not span different building finishes.
- FF. 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.
- GG. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- HH. Set metal floor boxes level and flush with finished floor surface.
- II. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
- 3.3 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."

3.4 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

SECTION 26 05 43

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

(Part of Work Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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, including GRC and PVC-coated steel conduit.
 - 2. Rigid nonmetallic duct.
 - 3. Duct accessories.
 - 4. Precast concrete handholes.
 - 5. Polymer concrete handholes and boxes with polymer concrete cover.
 - 6. Fiberglass handholes and boxes with polymer concrete cover.
 - 7. Fiberglass handholes and boxes.
 - 8. High-density plastic boxes.
 - 9. Precast manholes.

1.3 DEFINITIONS

- A. Direct Buried: Duct or a duct bank that is buried in the ground, without any additional casing materials such as concrete.
- B. Duct: A single duct or multiple ducts. Duct may be either installed singly or as component of a duct bank.
- C. Duct Bank:
 - 1. Two or more ducts installed in parallel, with or without additional casing materials.
 - 2. Multiple duct banks.
- D. GRC: Galvanized rigid (steel) conduit.
- E. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include duct-bank materials, including spacers and miscellaneous components.
 - 2. Include duct, conduits, and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
 - 3. Include accessories for manholes, handholes, boxes, and other utility structures.
 - 4. Include underground-line warning tape.
 - 5. Include warning planks.
- B. Shop Drawings:
 - 1. Precast or Factory-Fabricated Underground Utility Structures:
 - a. Include plans, elevations, sections, details, attachments to other work, and accessories.
 - b. Include duct entry provisions, including locations and duct sizes.
 - c. Include reinforcement details.
 - d. Include frame and cover design and manhole chimneys.
 - e. Include ladder/step details.
 - f. Include grounding details.
 - g. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
 - h. Include joint details.
 - 2. 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.
 - c. Include cover design.
 - d. Include grounding details.
 - e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: For duct and duct bank. Show duct profiles and coordination with other utilities and underground structures.
 - 1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
 - 2. Drawings shall be signed and sealed by a qualified professional engineer.
- B. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.

- C. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C858.
- D. Source quality-control reports.
- E. Field quality-control reports.

1.6 MAINTENANCE MATERIALS 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. Two sets of conduit sealing devices (duct plugs) for each conduit size installed.
 - 2. One reel of pull rope.
 - 3. Four pieces of spare manhole cable racking hardware (hooks or brackets).
 - 4. Underground warning tape, one roll.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM E329 for testing indicated.
- B. Pre-cast concrete manhole design shall be signed and stamped by a Massachusetts registered professional engineer.

1.8 FIELD CONDITIONS

- A. Ground Water: Assume ground-water level is at grade level unless a lower water table is noted on Drawings.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND FITTINGS

- A. GRC: Comply with ANSI C80.1 and UL 6.
- B. Coated Steel Conduit: PVC-coated GRC.
 - 1. Comply with NEMA RN 1.
 - 2. Coating Thickness: 0.040 inch (1 mm), minimum.
- C. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems; a part of Atkore International.
 - 2. Allied Tube & Conduit; a part of Atkore International.

3. Republic Conduit.
4. Thomas & Betts Corporation; A Member of the ABB Group.
5. Wheatland Tube Company.

- D. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

2.2 RIGID NONMETALLIC DUCT

- A. Underground Plastic Utilities Duct: Type EPC-40-PVC RNC, complying with NEMA TC 2 and UL 651, with matching fittings complying with NEMA TC 3 by same manufacturer as duct.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ARNCO Corp.
 2. Beck Manufacturing.
 3. Cantex, Inc.
 4. CertainTeed Corporation.
 5. Condux International, Inc.
 6. ElecSys, Inc.
 7. Electri-Flex Company.
 8. IPEX Inc.
 9. Lamson & Sessions; Carlon Electrical Products.
 10. Spiraduct/AFC Cable Systems, Inc.
- C. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
- D. Solvents and Adhesives: As recommended by conduit manufacturer.

2.3 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.
- B. Underground-Line Warning Tape: Comply with requirements for underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."
- C. Concrete Warning Planks: Nominal 12 by 24 by 3 inches (300 by 600 by 75 mm) in size, manufactured from 6000-psi (41-MPa) concrete.
1. Color: Red dye added to concrete during batching.
 2. Mark each plank with "ELECTRIC" in 2-inch- (50-mm-) high, 3/8-inch- (10-mm-) deep letters.

2.4 PRECAST CONCRETE HANDHOLES AND BOXES

- A. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Christy Concrete Products.
 - 2. Oldcastle Precast, Inc.
 - 3. Riverton Concrete Products.
 - 4. Utility Vault Co.
- C. Comply with ASTM C858 for design and manufacturing processes.
- D. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
- E. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- F. Cover Legend: Molded lettering, "ELECTRIC" or "COMMUNICATIONS."
- G. Configuration: Units shall be designed for flush burial and have integral closed bottom unless otherwise indicated.
- H. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
 - 1. Extension shall provide increased depth of 12 inches (300 mm).
 - 2. Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.
- I. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.
- J. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
 - 1. Type and size shall match fittings to duct to be terminated.
 - 2. Fittings shall align with elevations of approaching duct and be located near interior corners of handholes to facilitate racking of cable.
- K. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.5 POLYMER CONCRETE HANDHOLES AND BOXES WITH POLYMER CONCRETE COVER

- A. Description: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Armorcast Products Company.
 - 2. Hubbell Incorporated (Power Systems Group - Quazite).
 - 3. Oldcastle Enclosure Solutions.
 - 4. Carson industries LLC.
- C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
- D. Color: Gray.
- E. Configuration: Units shall be designed for flush burial and have integral closed bottom unless otherwise indicated.
- F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
- G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- H. Cover Legend: Molded lettering, "ELECTRIC" or "COMMUNICATIONS."
- I. 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.
- J. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.
- K. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.6 FIBERGLASS HANDHOLES AND BOXES WITH POLYMER CONCRETE FRAME AND COVER

- A. Description: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Armorcast Products Company.
 - 2. Carson Industries LLC.
 - 3. NewBasis.

4. Quazite: Hubbell Power System, Inc.

- C. Standard: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
- D. Color: Gray or Green. Coordinate color for each box based on location with Architect prior to ordering.
- E. Configuration: Units shall be designed for flush burial and have integral closed bottom unless otherwise indicated.
- F. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
- G. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- H. Cover Legend: Molded lettering, "ELECTRIC" or "COMMUNICATIONS."
- I. 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.
- J. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering duct for secure, fixed installation in enclosure wall.
- K. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2.7 PRECAST MANHOLES

- A. Description: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Christy Concrete Products.
 - 2. Oldcastle Precast, Inc.
 - 3. Riverton Concrete Products.
 - 4. Utility Vault Co.
 - 5. Or approved equal.
- C. Comply with ASTM C858.
- D. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.
- E. Knockout Panels: Precast openings in walls, arranged to match dimensions and elevations of approaching duct, plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.

1. Location as per drawings.
 2. Knockout panels shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
 3. Knockout panel opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct.
 4. Knockout panel shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
 5. Knockout panels shall be 1-1/2 to 2 inches (38 to 50 mm) thick.
- F. Duct Entrances in Manhole Walls: Cast end-bell fitting in wall for each entering duct.
1. Type and size shall match fittings to duct to be terminated.
 2. Fittings shall align with elevations of approaching duct and be located near interior corners of manholes to facilitate racking of cable.
- G. Ground Rod Sleeve: Provide a 3-inch (75-mm) PVC sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the duct entering the structure.
- H. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.
1. 1" Diameter Butyl Rubber or approved equal.

2.8 SOURCE QUALITY CONTROL

- A. Test and inspect precast concrete utility structures according to ASTM C1037.
- B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
1. Tests of materials shall be performed by an independent testing agency.
 2. Strength tests of complete boxes and covers shall be by an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 3. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

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 the field. Notify Architect if there is a 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 according to Section 31 00 00 "Earthwork." Remove and stockpile topsoil for reapplication according to Section 31 00 00 "Earthwork."

3.2 UNDERGROUND DUCT APPLICATION

- A. Duct for Electrical Cables More Than 600 V: Type EPC-40-PVC RNC, concrete-encased unless otherwise indicated.
- B. Duct for Electrical Feeders 600 V and Less: Type EPC-40-PVC RNC, concrete-encased unless otherwise indicated.
- C. Duct for Electrical Branch Circuits: Type EPC-80-PVC RNC, direct-buried unless otherwise indicated.
- D. Underground Ducts Crossing Paved Paths, Walks, and Driveways Type EPC-40 PVC RNC, encased in reinforced concrete.
- E. Stub-ups: Concrete-encased PVC-coated GRC.
- F. PVC coated steel conduits shall be used in lieu of rigid nonmetallic conduit for the following conditions or locations:
 - 1. Where exposed to weather.
 - 2. Use for all conduit stub-ups through the floor slab, including the elbows.
 - 3. Use for all conduit penetrations through the exterior walls, including five feet on either side of the penetration.
 - 4. All conduits and fittings that have a damaged PVC coating shall be replaced promptly.

3.3 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for 600 V and Less:

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 a 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 according to SCTE 77 with 3000-lbf (13 345-N) vertical loading.
5. Cover design load shall not exceed the design load of the handhole or box.

B. Manholes: Precast concrete.

1. Concrete minimum strength - 5000 psi @ 28 days.
2. Steel reinforcement - ASTM A615, Grade 60.
3. Minimum Steel Cover - 1inch.
4. Design Loading - AASHTO HS20-44.
5. Design Specifications - ACI 318 & AASHTO Load Factor Design Method.
6. Manufacturer's name and year of fabrication shall be stenciled on vertical wall of access chimney.
7. Termaducts may be specified in lieu of knockouts at the direction of NSTAR

3.4 EARTHWORK

- A. Excavation and Backfill: Comply with Section 31 00 00 "Earthwork," but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restoration: Replace area after construction vehicle traffic in immediate area is complete.
- 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. Cut and patch existing pavement in the path of underground duct, duct bank, and underground structures according to Section 01 73 29 "Cutting and Patching" and 32 13 13 "Portland Cement Concrete Pavement."

3.5 DUCT AND DUCT-BANK INSTALLATION

- A. Where indicated on Drawings, install duct, spacers, and accessories into the duct-bank configuration shown. Duct installation requirements in this Section also apply to duct bank.

- B. Install duct according to NEMA TCB 2.
- C. Slope: Pitch duct a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope duct from a high point between two manholes, to drain in both directions.
- D. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches (1200 mm), both horizontally and vertically, at other locations unless otherwise indicated. Use PVC coated rigid conduit for all bends for ducts for electrical cables more than 600 V, and for all equipment and device stub-ups for ducts for electrical cables less than 600 V.
 - 1. Duct shall have maximum of two 90 degree bends or the total of all bends shall be no more 180 degrees between pull points.
- E. Joints: Use solvent-cemented joints in duct and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent duct do not lie in same plane.
- F. Installation Adjacent to High-Temperature Steam Lines: Where duct is installed parallel to underground steam lines, perform calculations showing the duct will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.
- G. End Bell Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches (250 mm) o.c. for 5-inch (125-mm) duct, and vary proportionately for other duct sizes.
 - 1. Begin change from regular spacing to end-bell spacing 10 feet (3 m) from the end bell, without reducing duct slope and without forming a trap in the line.
 - 2. Expansion and Deflection Fittings: Install an expansion and deflection fitting in each duct in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line direct-buried duct with calculated expansion of more than 3/4 inch (19 mm).
 - 3. Grout end bells into structure walls from both sides to provide watertight entrances.
- H. Building Wall Penetrations: Make a transition from underground duct to GRC at least 10 feet (3 m) outside the building wall, without reducing duct line slope away from the building and without forming a trap in the line. Use fittings manufactured for RNC-to-GRC transition. Install GRC penetrations of building walls as specified in Section 26 05 44 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
- I. 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 (1.03-MPa) hydrostatic pressure.
- J. Pulling Cord: Install 200-lbf- (1000-N-) test nylon cord in empty ducts.

K. Concrete-Encased Ducts and Duct Bank:

1. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified in Section 31 00 00 "Earthwork" for pipes less than 6 inches (150 mm) in nominal diameter.
2. Width: Excavate trench 12 inches (300 mm) wider than duct on each side.
3. Width: Excavate trench 3 inches (75 mm) wider than duct on each side.
4. Depth: Install so top of duct envelope is at least 24 inches (600 mm) below finished grade in areas not subject to deliberate traffic, and at least 30 inches (750 mm) below finished grade in deliberate traffic paths for vehicles unless otherwise indicated.
5. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
6. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet (6 m) of duct. Place spacers within 24 inches (600 mm) of duct ends. Stagger spacers approximately 6 inches (150 mm) 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.
7. Minimum Space between Duct: 3 inches (75 mm) between edge of duct and exterior envelope wall, 2 inches (50 mm) between ducts for like services, and 4 inches (100 mm) between power and communications ducts.
8. Elbows: Use manufactured PVC coated rigid steel conduit elbows for stub-ups at poles and equipment, and at changes of direction in duct run.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
 - b. Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of base. Install insulated grounding bushings on terminations at equipment.
 - c. Stub-Ups to Equipment: For indoor equipment, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of wall. Install insulated grounding bushings on terminations at equipment.
9. 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.
10. 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.
11. Concrete Cover: Install a minimum of 3 inches (75 mm) of concrete cover between edge of duct to exterior envelope wall, 2 inches (50 mm) between duct of like services, and 4 inches (100 mm) between power and communications ducts.
12. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
 - a. Start at one end and finish at the other, allowing for expansion and contraction of duct as its temperature changes during and after the

- pour. Use expansion fittings installed according to manufacturer's written instructions, or use other specific measures to prevent expansion-contraction damage.
- b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch (15-mm) reinforcing-rod dowels extending a minimum of 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.
13. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 03 30 00 "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 a heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.
- L. Direct-Buried Duct and Duct Bank:
1. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 31 00 00 "Earthwork" for preparation of trench bottoms for pipes less than 6 inches (150 mm) in nominal diameter.
 2. Width: Excavate trench 12 inches (300 mm) wider than duct on each side.
 3. Width: Excavate trench 3 inches (75 mm) wider than duct on each side.
 4. Depth: Install top of duct at least 36 inches (900 mm) below finished grade unless otherwise indicated.
 5. Set elevation of bottom of duct bank below frost line.
 6. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
 7. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 feet (6 m) of duct. Place spacers within 24 inches (600 mm) of duct ends. Stagger spacers approximately 6 inches (150 mm) 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.
 8. Install duct with a minimum of 3 inches (75 mm) between ducts for like services and 6 inches (150 mm) between power and communications duct.
 9. Elbows: Install manufactured duct elbows for stub-ups, at building entrances, and at changes of direction in duct direction unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
 10. Install manufactured PVC coated rigid steel conduit elbows for stub-ups at poles and equipment, at building entrances, and at changes of direction in duct.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
 - b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

- c. **Stub-Ups to Equipment:** For indoor equipment, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of wall. Install insulated grounding bushings on terminations at equipment.
 - 11. 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 inches (100 mm) 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 31 00 00 "Earthwork" for installation of backfill materials.
 - a. Place minimum 6 inches (150 mm) of engineered fill above concrete encasement of duct.
 - M. **Warning Planks:** Bury warning planks approximately 12 inches (300 mm) above direct-buried duct, placing them 24 inches (600 mm) o.c. Align planks along the width and along the centerline of duct or duct bank. Provide an additional plank for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional planks 12 inches (300 mm) apart, horizontally.
 - N. **Underground-Line Warning Tape:** Bury warning tape specified in Section 26 05 53 "Identification for Electrical Systems" no less than 12 inches (300 mm) above all concrete-encased duct and duct banks. Align tape parallel to and within 3 inches (75 mm) of centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.
- 3.6 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES
- A. **Precast Concrete Handhole and Manhole Installation:**
 - 1. Comply with ASTM C891 unless otherwise indicated.
 - 2. Install units level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances.
 - 3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1-inch (25-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
 - B. **Elevations:**
 - 1. **Manhole Roof:** Install with rooftop at least 15 inches (375 mm) below finished grade.
 - 2. **Manhole Frame:** In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames 1 inch (25 mm) above finished grade.
 - 3. Install handholes with bottom below frost line

4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
 5. Where indicated, cast handhole cover frame integrally with handhole structure.
- C. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.
- D. Manhole Access: Circular opening in manhole roof; sized to match cover size.
1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
 2. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.
- E. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
- F. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches (97 mm) for manholes and 2 inches (50 mm) for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.7 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

- A. 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.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.
- D. Install handholes and boxes with bottom below frost line.
- E. 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.
- F. Field cut openings for duct according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size

holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.8 GROUNDING

- A. Ground underground ducts and utility structures according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.9 FIELD QUALITY CONTROL

- A. Perform the following 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 a minimum 12-inch- (300-mm-) long mandrel equal to duct size minus 1/4 inch (6 mm). If obstructions are indicated, remove obstructions and retest.
 - 3. Test manhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 26 05 26 "Grounding and Bonding for Electrical Systems."
- B. Correct deficiencies and retest as specified above to demonstrate compliance.
- C. Prepare test and inspection reports.

3.10 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.
 - 1. Sweep floor, removing dirt and debris.
 - 2. Remove foreign material.

END OF SECTION

SECTION 26 05 44

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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 for raceway and cable penetration of non-fire-rated construction walls and floors.
- 2. Sleeve-seal systems.
- 3. Sleeve-seal fittings.
- 4. Grout.
- 5. Silicone sealants.

B. Related Requirements:

- 1. Section 07 84 13 "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Wall Sleeves:
 - 1. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.
- C. PVC-Pipe Sleeves: ASTM D1785, Schedule 40.
- D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.
- E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
- F. Sleeves for Rectangular Openings:
 - 1. Material: Galvanized sheet steel.
 - 2. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advance Products & Systems, Inc.
 - b. BWM Company.
 - c. CALPICO, Inc.
 - d. Flexicraft Industries.
 - e. Metraflex Company (The).
 - f. Pipeline Seal and Insulator, Inc.
 - g. Proco Products, Inc.
 2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 3. Pressure Plates: Stainless steel.
 4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. HOLDRITE; Reliance Worldwide Company.

2.4 GROUT

- A. Description: Nonshrink; recommended 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 (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. 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 annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 07 92 00 "Joint Sealants."

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

- b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
 - 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 inches (50 mm) above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
- 1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using [steel] [cast-iron] pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- 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.

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.

END OF SECTION

SECTION 26 05 48

SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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. Restraint channel bracings.
2. Restraint cables.
3. Seismic-restraint accessories.
4. Mechanical anchor bolts.
5. Adhesive anchor bolts.

B. Related Requirements:

1. Section 26 05 29 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
 - a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
 - b. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated-Design Submittal: For each seismic-restraint device.

1. Include design calculations and details for selecting seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Design Calculations: Calculate static and dynamic loading caused by equipment weight, operation, and seismic and wind forces required to select seismic and wind restraints and for designing vibration isolation bases.
 - a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
3. Seismic- and Wind-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic and wind restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

- c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
- d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints. Electrical components include:
 - 1. Control and monitoring panels.
 - 2. Generators.
 - 3. Transfer switches.
 - 4. Luminaires.
 - 5. Panelboards.
 - 6. Photovoltaic system components.
 - 7. Switchboards.
 - 8. Transformers.
- B. Qualification Data: For professional engineer and testing agency.
- C. Welding certificates.
- D. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated and that is acceptable to authorities having jurisdiction.

- B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis. They shall bear anchorage preapproval from OSHPD in addition to preapproval, showing maximum seismic-restraint ratings, by ICC-ES or another agency acceptable to authorities having jurisdiction. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) that support seismic-restraint designs must be signed and sealed by a qualified professional engineer.
- E. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Wind-Restraint Loading:
 - 1. Basic Wind Speed: 131 mph.
 - 2. Building Classification Category: IV.
 - 3. Minimum 10 lb/sq. ft. (48.8 kg/sq. m) multiplied by maximum area of component projected on vertical plane normal to wind direction and 45 degrees either side of normal.
- B. Seismic-Restraint Loading:
 - 1. Site Class as Defined in the IBC: D.
 - 2. Assigned Seismic Use Group or Building Category as Defined in the IBC: IV.
 - a. Component Importance Factor: 1.5.
 - b. Component Response Modification Factor: 3.0.

c. Component Amplification Factor: 2.5.

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): in accordance with 780 CMR and ASCE/SEI 7-05.
4. Design Spectral Response Acceleration at 1.0-Second Period: in accordance with 780 CMR and ASCE/SEI 7-05.

2.2 RESTRAINT CHANNEL BRACINGS

- A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end, with other matching components, and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.3 RESTRAINT CABLES

- A. Restraint Cables: ASTM A603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.4 SEISMIC-RESTRAINT ACCESSORIES

- A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.
- B. 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.
- C. 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.
- D. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.5 MECHANICAL ANCHOR BOLTS

- A. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for 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 Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.
- B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods caused by seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

- A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 03 30 00 "Cast-in-Place Concrete."

B. Equipment and Hanger Restraints:

1. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
2. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. 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.

E. 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.

F. Drilled-in 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 the 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. Wedge Anchors: 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 Anchors: 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 SEISMIC MOTION

- A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 2. 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.
 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 5. Test to 90 percent of rated proof load of device.
- C. Seismic controls will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION

SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

(Part Of Work Of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve sustainable design, measured and documented according to USGBC LEED-NC v4 rating system. Refer to Sections 018110, SUSTAINABLE DESIGN REQUIREMENTS and 018120 CONSTRUCTION INDOOR AIR QUALITY MANAGEMENT for additional requirements

1.2 SUMMARY

- A. Section Includes:
 - 1. Identification for raceways
 - 2. Identification of conduits
 - 3. Identification of circuits
 - 4. Warning labels and signs
 - 5. Labeled device cover plates
 - 6. Equipment nameplates
 - 7. Panelboard directories
 - 8. Identification of junction box
- B. Related work: Consult all other Sections, determine the extent and character of related work and properly coordinate work specified herein with that specified elsewhere to produce a complete installation.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Data/catalog cutsheets for each product and component specified herein.
 - 2. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

3. 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.
- B. Delegated-Design Submittal: For arc-flash hazard study.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with ASME A13.1 and IEEE C2.
- 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. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

2.2 MANUFACTURERS

- A. Conduit and circuit markers:
 1. Brady Corporation
 2. Emedco
 3. Marking Services, Inc.
 4. Carlton Industries, LP
 5. Panduit
 6. Approved Equal.
- B. Inscription Tape:
 1. Brady Corporation
 2. Carlton Industries, LP
 3. Marking Services, Inc
 4. Approved Equal.

2.3 LABELS

- A. Lighting and Power Branch Circuiting Labeling

1. Self-Adhesive Wraparound Labels: Preprinted or write-on, 3-mil-thick, minimum 3/4-inch wide, vinyl flexible label with acrylic pressure-sensitive adhesive.
 - a. 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.
 - b. Marker for Labels:
 - 1) Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

2.4 INSCRIPTION TAPE & STENCILS

A. Feeder & Branch Circuit over #4AWG in Distribution Panels

1. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

B. Conductor Phase Markers

1. For identification of phase conductors and voltage level:
 - 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.

C. Inscription Tape Labeling

1. Cover plate material shall be as specified in Section 26 27 26: Wiring Devices.
2. Provide P-touch self-adhesive labeling tape:
 - a. 1/8" high letters

2.5 TAGS

A. Feeder Identification in Boxes

1. Metal Tags: Brass
 - a. Type BT: Metal tags with die-stamped legend, punched for use with self-locking cable fastener.
 - b. Round Dimensions: 2-inch diameter, 19 gauge (0.036in)
2. Nonmetallic Preprinted Tags: Polyethylene tags, 0.023-inch-thick, color-coded for phase and voltage level, with factory screened or printed permanent designations; punched for use with self-locking cable tie fastener.
3. Write-on Tags:
 - a. Polyester Tags: 0.015-inch-thick, with corrosion-resistant grommet and cable tie for attachment.
 - b. Marker for Tags:
 - 1) Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer

2.6 SIGNS

A. Indoor

1. Baked-Enamel Signs:
 - a. Preprinted aluminum signs, high-intensity reflective punched or drilled for fasteners, with colors, legend, and size required for application.
 - b. 1/4-inch grommets in corners for mounting.
 - c. Nominal Size: 7 by 10 inches.
2. Laminated Acrylic or Melamine Plastic Signs
 - a. Engraved legend.
 - b. Thickness:
 - 1) For signs up to 20 sq. in., minimum 1/16 inch thick.
 - 2) For signs larger than 20 sq. in., 1/8 inch thick.
 - 3) Engraved legend with black letters on white face unless otherwise noted in this specification or on drawings.
 - 4) Punched for mechanical fasteners with 1/4-inch grommets in corners for mounting.
 - 5) Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. Outdoor

1. Metal-Backed Butyrate Signs:
 - a. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
 - b. 1/4-inch grommets in corners for mounting.
 - c. Nominal Size: 10 by 14 inches.

2.7 NAMEPLATES

A. Type NP: Engraved, Lamacoid label and instruction plates.

1. Engraved legend.
2. Thickness:
 - a. Engrave nameplates 1/16-inch minimum thickness for signs up to 4 inches in length, 1/8-inch thick for larger sizes.
 - b. Engraved legend with black letters on white face unless otherwise noted in this specification or on drawings.
 - c. Punched for mechanical fasteners with 1/4-inch grommets in corners for mounting.
 - d. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

B. The lettering shall be Condensed Gothic with space between the lines equal to the width of the letters.

- C. Color and letter height as specified in Part 3: Execution.

2.8 PANELBOARD DIRECTORIES

- A. Directories: A 6-inch x 8-inch minimum size circuit directory frame and card with clear plastic covering shall be provided inside the inner panel door.
- B. Circuit numbering: Starting at the top, odd numbered circuits in sequence down the left-hand side and even numbered circuits down the right-hand side.

2.9 CABLE TIES

- A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 Deg F according to ASTM D638: 12,000 psi.
 - 3. Temperature Range: Minus 40 to plus 185 deg F.
 - 4. Color: Black, except where used for color-coding.
- B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 Deg F according to ASTM D638: 12,000 psi.
 - 3. Temperature Range: Minus 40 to plus 185 deg F.
 - 4. Color: Black.
- C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 Deg F according to ASTM D638: 7000 psi.
 - 3. UL 94 Flame Rating: 94V-0.
 - 4. Temperature Range: Minus 50 to plus 284 deg F.
 - 5. Color: Black.

2.10 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 EXAMINATION

- A. Thoroughly examine site conditions for acceptance of identification device installation to verify conformance with manufacturer and specification tolerances. Do not commence with installation until all conditions are made satisfactory.

3.3 NAMEPLATES

- A. Equipment to have nameplates includes but is not limited to the following:

1. Panelboards
2. Enclosures and electrical cabinets.
3. Access doors and panels for concealed electrical items.
4. Switchboards.
5. Transformers.
6. Emergency system boxes and enclosures.
- 7.
8. Enclosed switches.
9. Enclosed circuit breakers.
10. Enclosed controllers.
11. Variable-speed controllers.
12. Push-button stations.
13. Power-transfer equipment.
14. Contactors.
15. Remote-controlled switches, dimmer modules, and control devices.
16. Battery-inverter units.
17. Battery racks.
18. Power-generating units.
19. Monitoring and control equipment.
20. UPS equipment.

- B. Color Identification:

1. Nameplates for normal power system and standby generator power distribution equipment and devices shall be black with white lettering.
2. Nameplates for emergency power system distribution equipment and devices shall be green with white lettering.

3. Nameplates for signal systems equipment and devices shall be blue with white lettering.
 4. Nameplates for Fire Alarm systems equipment and devices shall be red with white lettering.
 5. Nameplates for UPS panel shall be orange with white lettering.
 6. Nameplates for UPS System A equipment shall be orange with white lettering.
 7. Nameplates for UPS System B equipment shall be blue with white lettering.
- C. Installation:
1. Degrease and clean surfaces to receive nameplates.
 2. Install nameplates parallel to equipment lines.
 3. Secure nameplates to equipment fronts using machine screws.
- D. Nameplate lettering for switchgear, switchboard, and panelboard shall include and coincide with the naming scheme on the drawings:
1. Type of equipment
 2. Name of equipment & unit number
 3. Voltage
 4. Phases
 5. Wires
 6. Feed from.
 7. Panelboard sample:
 - a. Panelboard, LP-3A-H-2 480/277V, 3 phase, 4 wire, Fed From US-1.
- E. Nameplate lettering for electrical distribution equipment (e.g transformers, disconnects, enclosed circuit breakers, ups, battery cabinet etc.) shall include and coincide with the naming scheme on the drawings:
1. Type of equipment
 2. Name of equipment & unit number
 3. Equipment rating (e.g. amperage, KVA or horsepower rating, where applicable)
 4. Voltage system
 5. Fed from (system source)
 6. Typical samples:
 - a. Transformer, XFMR – PP-1A; 45kVA; 208V- 480V/277V, Fed From USB.
 - b. Disconnect, AH-1; 25HP; 480V, Fed From SWBD-3B.
 - c. Variable Frequency Drive, CHWP-2; 10HP; 480V, Fed From DP-2A.
 - d. Automatic Transfer Switch, ATS -2, 1200A, 480V, Normal Fed From SWBD-1A, Emergency Fed From ESWBD-1A
- F. Minimum letter height shall be as follows:
1. For switchgear, switchboards, panelboards, transformers, motor control centers etc.: 1/2-inch letters to identify equipment designation. Use 1/4-inch letters to identify the remaining items.
 2. For individual circuit breakers, disconnect switches and motor starters in switchboards and motor control centers use 3/8-inch letters to identify equipment designation. Use 1/8- inch letters to identify the remaining items.

3. For individual mounted circuit breakers, disconnect switches, enclosed switches and motor starters use 3/8-inch letters to identify equipment designation. Use 1/8-inch letters to identify the remaining items.
4. For equipment cabinets, terminal cabinets, control panels and other cabinet enclosed apparatus use 1/4-inch letters to identify equipment designation.

3.4 PANELBOARD IDENTIFICATION

- A. Provide typewritten directories arranged in numerical order denoting loads served by room number or area for each circuit.
- B. Fill out branch circuit directory indicating, but not limited to, the following:
 1. Circuit number
 2. Area served (i.e. rooms, group of rooms, etc.)
 3. Type of load served (i.e. lighting, convenience outlets, motors, etc.)
- C. Card index shall be neatly typed.
- D. Mount panelboard directories in a metal frame under clear plastic cover inside every panelboard.
- E. Provide wire markers on each conductor in panelboards
 1. Sample: #11

3.5 CONDUCTOR IDENTIFICATION

- A. Provide colored phase markers for conductors as noted in Section 26 05 19. Apply colored, pressure sensitive plastic tape in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply the last two laps of tape with no tension to prevent possible unwinding. Do not cover cable identification markings by taping.
- B. Conductors to Be Extended in the Future: Attach write-on tags or marker tape to conductors and list source.
- C. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
- D. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use self-adhesive wraparound labels or self-adhesive vinyl tape to identify the phase.
 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

- E. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use write-on tags or nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation.
- F. Circuit Identification
 - 1. Metal Tags: Provide type BT tags for individual ground conductors to exposed ground bus indicating connection i.e. "UFER", "Cold water bond", etc.
 - a. Provide tags for all feeder cables in underground vaults and pull boxes.
 - b. Provide tags for empty conduits in underground vault, pull boxes, and stubs.
 - c. Place in a location with high visibility and accessibility.
 - d. Secure using appropriate cable ties
 - 2. Identify each feeder and branch circuit wire with panel name and circuit number.

3.6 CONDUIT AND BOXES IDENTIFICATION

- A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive raceway labels or vinyl tape applied in bands.
 - 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- B. Color Identification:
 - 1. Color code or label all junction boxes and exposed conduit at 10 ft. intervals. Coding shall be painted or labels of the pre-manufactured type permanently mounted with metal or plastic band.
 - 2. Provide a color identification scheme under heavy plastic cover hanging in the electrical rooms; identification shall be:
 - a. Emergency - Orange.
 - b. Normal - Black
 - c. Fire Alarm - Red
 - d. Security - Green
 - e. AV / Sound - Blue
 - f. Voice / Data - Yellow.
 - 3. All conduit for signal system shall be color coded with 6" wide spray paint for every 10' of length.
 - 4. All outlet boxes (inside and outside) for signal system shall be color coded.
- C. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil. Stencil legend "DANGER - CONCEALED HIGH-VOLTAGE WIRING" with 3-inch-high, black letters on 20-inch centers.

1. Locate identification at changes in direction, at penetrations of walls and floors, and at 30-foot maximum intervals.

3.7 WARNING, CAUTION AND INSTRUCTION SIGNS

- A. Provide warning, caution, or instruction signs where required by NEC, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install engraved plastic laminated acrylic, melamine, or baked-enamel instruction signs with legend, where instructions or explanations are needed for system and/or equipment operation. Install butyrate signs with metal backing for outdoor items.
- B. Emergency Operating Instruction Signs: Install engraved laminate signs with white letters on red background with minimum 3/8-inch high lettering for emergency instructions on power transfer, load shedding, or other emergency operations.
- C. Elevator Machine Rooms(s): Provide warning sign for each elevator controller disconnect to read "WARNING - PART OF THE CONTROL PANEL IS NOT DE-ENERGIZED BY THIS SWITCH."
- D. Elevator car light and fan switch: Provide signage indicating elevator number serving and function of each switch.
- E. Warning signs to be included on doors or immediately above doors of all electrical equipment rooms, vaults or closets containing equipment energized above 150 volts to ground. The sign shall state "DANGER - HIGH VOLTAGE - KEEP OUT", with "DANGER" in 1-1/2" letters and "HIGH VOLTAGE - KEEP OUT" in 1-inch letters.
- F. Additional warning signs shall include, but are not limited to the following:
 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."

3.8 LABELED DEVICE COVERPLATE

- A. Application:
 1. Provide labeled cover plates for devices as outlined below:
 - a. Receptacles
 - b. Outlets in surface raceways.
 - c. Multi-ganged (four or more) switch arrangement.
 - d. Special purpose switches, i.e. projection screens, shades, exhaust fans, etc.
- B. Each receptacle outlet shall be labeled with black filled letters, circuit number and panel name.

1. Sample: LP-1A/#23

3.9 LIGHTING FIXTURE IDENTIFICATION

- A. Provide permanent labels indicating panel name, circuit number, and lamp type. The labels shall be clearly visible from above the ceiling, but not below.

3.10 CABLE TIES

- A. General purpose, for attaching tags, except as listed below:
 1. Outdoors: UV-stabilized nylon.
 2. In Spaces Handling Environmental Air: Plenum rated

3.11 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.
- G. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
 1. Secure tight to surface of conductor, cable, or raceway.
- H. System Identification for Raceways and Cables over 600 V: Identification shall completely encircle cable or conduit. Place adjacent identification of two-color markings in contact, side by side.
 1. Secure tight to surface of conductor, cable, or raceway.
- I. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.

- J. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.
- K. Self-Adhesive Labels:
 - 1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
 - 2. Unless otherwise indicated, provide a single line of text with 1/2-inch high letters on 1-1/2-inch high label; where two lines of text are required, use labels 2 inches high.
- L. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.
- M. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.
- N. Tape and Stencil: Comply with requirements in painting Sections for surface preparation and paint application.
- O. Baked-Enamel Signs:
 - 1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
 - 2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.
- P. Metal-Backed Butyrate Signs:
 - 1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
 - 2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.
- Q. Laminated Acrylic or Melamine Plastic Signs:
 - 1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
 - 2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high sign; where two lines of text are required, use labels 2 inches high.
- R. Nameplates shall be secured with either #4 Phillips, round head corrosion resistant steel self-tapping screws or with pop rivets, one on each end.
- S. Signs shall be permanently mounted with cadmium plated, steel screws.
- T. Receptacles shall have circuit number and panelboards identification label permanently attached to face of respective cover plate.

- U. High voltage circuits and equipment shall have engraved nameplates suitable for environment involved.
- V. Provide a full-size glass framed photocopy of single line diagram on wall adjacent to main gears.
- W. Warning Signs:
 - 1. Contractor shall provide OSHA warning signs where required by National Electrical Code and OSHA.
 - 2. Low and medium voltage equipment enclosures, vaults, doors and fences shall be provided with "DANGER KEEP OUT" warning signs, showing proper voltage.
 - 3. Non-load-break disconnects, and cutouts shall have "CAUTION" warning sign to read "DO NOT OPEN UNDER LOAD".

END OF SECTION

SECTION 26 05 73

OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY AND ARC FLASH ANALYSIS

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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. Computer-based, overcurrent protective device coordination studies to determine system available short circuit current, minimum interrupting capacity of circuit protective devices, and to determine overcurrent protective device settings for selective tripping.
 - 2. Arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.3 DEFINITIONS

- A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.
- B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

- C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- D. SCCR: Short-circuit current rating.
- E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 ACTION SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals may be in digital form.
 - 1. Study input data, including completed computer program input data sheets.
 - 2. Study and equipment evaluation reports.
 - 3. Overcurrent protective device coordination study and arc-flash hazard analysis report; signed, dated, and sealed by a qualified professional engineer.
 - a. Submit study report for action prior to receiving final approval of the 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 the selection of devices and associated characteristics is satisfactory.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Study Specialist.
- B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01 10 00 "General Requirements," include the following:
 - a. The following parts from the Protective Device Coordination Study Report:
 - 1) One-line diagram.
 - 2) Protective device coordination study.
 - 3) Time-current coordination curves.
 - b. Power system data.

1.7 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

- A. Software Developers: Subject to compliance with requirements, provide software by one of the following:
 1. SKM Systems Analysis, Inc.
 2. Operation Technology, Inc. (ETAP)
 3. EasyPower LLC
- B. Comply with IEEE 242 and IEEE 399.

- C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.
 - 1. Additional Features:
 - a. Arcing faults.
 - b. Simultaneous faults.
 - c. Explicit negative sequence.
 - d. Mutual coupling in zero sequence.

2.2 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.
- C. One-line diagram, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Cable size and lengths.
 - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 - 4. Motor and generator designations and kVA ratings.
 - 5. Switchgear, switchboard, motor-control center, and panelboard designations.
- D. Study Input Data: As described in "Power System Data" Article.
- E. Comments and recommendations for system improvements, where needed.
- F. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
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 the 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.

G. Short-Circuit Study:

1. 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 a symmetrical basis.
 - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.
- H. Protective Device Coordination Study:
 1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the 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, 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.
- I. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination to 0.01 seconds for emergency and legally required systems and 0.1 seconds for normal and optional standby systems.

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 the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the 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. Low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
 - b. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
 - c. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
 - d. Cables and conductors damage curves.
 - e. Ground-fault protective devices.
 - f. Motor-starting characteristics and motor damage points.
 - g. The largest feeder circuit breaker in each motor-control center and panelboard.
5. Provide adequate time margins between device characteristics such that selective operation is achieved.
6. Clearly indicate on all time current curves when selectivity is obtained based on circuit breaker dynamic impedance. Provide manufacturer's documentation showing testing and verification of all breakers coordinated with dynamic impedance.
7. Comments and recommendations for system improvements.

8. Provide verification of circuit breaker coordination (include verification confirmation of coordination time ranges indicated above) from manufacturer where coordination is based on dynamic impedance or tested values and coordination is not readily apparent from provided time current curves. Indicate source of coordination information (including coordinated time range) on all graphs where coordination is not readily apparent by inspection.

2.3 SHORT-CIRCUIT STUDY REPORT CONTENT

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope.
- C. One-line diagram, showing the following:
 1. Protective device designations and ampere ratings.
 2. Cable size and lengths.
 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 4. Motor and generator designations and kVA ratings.
 5. Switchgear, switchboard, motor-control center and panelboard designations.
- D. Study Input Data: As described in "Power System Data" Article.
- E. 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. Working distance.
 6. Incident energy.
 7. Hazard risk category.

8. Recommendations for arc-flash energy reduction.

- F. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

2.4 ARC-FLASH WARNING LABELS

- A. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems." Produce a 3.5-by-5-inch (76-by-127-mm) thermal transfer label of high-adhesion polyester for each work location included in the analysis.
- B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the 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.
- C. Labels shall be machine printed, with no field-applied markings.

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. All circuit breakers and fuses are to be coordinated.

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 PROTECTIVE DEVICE 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. The study shall be based on the device characteristics supplied by device manufacturer.
- D. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:
 1. To low-voltage load buses where fault current is 10 kA or less and hazard risk category is 0.
- E. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- F. Transformer Primary Overcurrent Protective Devices:
 1. Device shall 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 shall protect transformers according to IEEE C57.12.00, for fault currents.
- G. Motor Protection:
 1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.

- H. 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 the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.
- I. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.
 - 1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
- J. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:
 - 1. Electric utility's supply termination point.
 - 2. Incoming medium voltage switchgear.
 - 3. Medium voltage transformer.
 - 4. Low-voltage switchboards.
 - 5. Control panels.
 - 6. Standby generators and automatic transfer switches.
 - 7. Branch circuit panelboards.
 - 8. Disconnect switches.
- K. Protective Device Evaluation:
 - 1. Evaluate equipment and protective devices and compare to short-circuit ratings.
 - 2. Adequacy of switchboard and panelboard bus bars to withstand short-circuit stresses.

3.3 LOAD-FLOW AND VOLTAGE-DROP STUDY

- A. Perform a load-flow and voltage-drop study to determine the steady-state loading profile of the 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 the design capacity of the load buses.
 - 3. Prepare the 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.

3.4 MOTOR-STARTING STUDY

- A. Perform a motor-starting study to analyze the transient effect of the system's voltage profile during motor starting. Calculate significant motor-starting voltage profiles and analyze the effects of the motor starting on the power system stability.
- B. Prepare the motor-starting study report, noting light flicker for limits proposed by IEEE 141, and voltage sags so as not to affect the operation of other utilization equipment on the system supplying the motor.

3.5 ARC-FLASH HAZARD ANALYSIS

- A. Comply with NFPA 70E and its Annex D for hazard analysis study.
- B. Use the short-circuit study output and the recommended settings of the overcurrent devices.
- C. Calculate maximum and minimum contributions of fault-current size.
 - 1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
 - 2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

- D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts. This includes all switchboards, panelboards, and motor-starters/disconnects/VFDs.
- E. Include low-voltage equipment locations.
- F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.
- G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators shall be decremented as follows:
 - 1. Fault contribution from induction motors should not be considered beyond three to five cycles.
 - 2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to three per unit after 10 cycles).
- H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:
 - 1. When the circuit breaker is in a separate enclosure.
 - 2. When the line terminals of the circuit breaker are separate from the 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.

3.6 POWER SYSTEM DATA

- A. Obtain all data necessary for the conduct of the overcurrent protective device study.
 - 1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Architect.

2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
- B. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 241 and IEEE 551 for the amount of detail required to be acquired.
1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 2. Electrical power utility impedance at the service.
 3. Power sources and ties.
 4. Short-circuit current at each system bus, three phase and line-to-ground.
 5. Full-load current of all loads.
 6. Voltage level at each bus.
 7. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
 8. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
 9. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
 10. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
 11. For relays, provide manufacturer and model designation, current transformer ratios, potential transformer ratios, and relay settings.
 12. Maximum demands from service meters.
 13. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.

14. Motor horsepower and NEMA MG 1 code letter designation.
15. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
16. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
 - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
 - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
 - c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
 - d. Ratings, types, and settings of utility company's overcurrent protective devices.
 - e. Special overcurrent protective device settings or types stipulated by utility company.
 - f. Time-current-characteristic curves of devices indicated to be coordinated.
 - g. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
 - h. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
 - i. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.
 - j. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.7 LABELING

- A. Apply one arc-flash label for 600-V ac, 480-V ac, and 208-V ac panelboards and disconnects and for each of the following locations:
 - 1. Low-voltage switchboard.
 - 2. Control panel.
 - 3. Panelboards
 - 4. Motor-starters
 - 5. Disconnects
 - 6. VFDs.

3.8 APPLICATION OF WARNING LABELS

- A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

3.9 FIELD ADJUSTING

- A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.10 DEMONSTRATION

- A. Engage the Coordination Study Specialist to train Owner's maintenance personnel in the following:
 - 1. Acquaint personnel in the fundamentals of operating the power system in normal and emergency modes.

2. Hand-out and explain the objectives of the coordination study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.
3. Adjust, operate, and maintain overcurrent protective device settings.
4. The potential arc-flash hazards associated with working on energized equipment and the significance of the arc-flash warning labels.

END OF SECTION

SECTION 26 06 50

SCHEDULES FOR LIGHTING

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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 includes the schedule for luminaires and associated lighting equipment.
- B. Related Sections:
 - 1. Consult all other Sections, determine the extent and character of related work and properly coordinate work specified herein with that specified elsewhere to produce a complete installation.
 - a. Section 26 09 43 – Digital Network Lighting Controls
 - b. Section 26 51 00 – Luminaires

PART 2 - PRODUCTS

2.1 LIGHTING FIXTURE SCHEDULE

- A. The luminaire schedule is shown on the following pages.

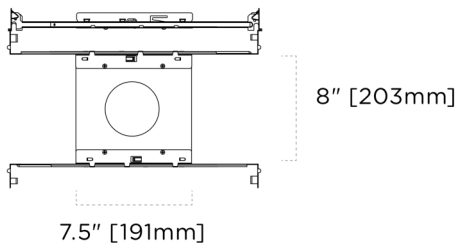
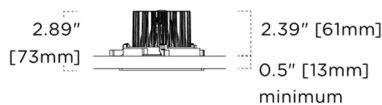
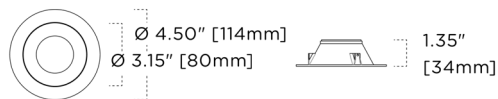
2.2 BREAKOUT BID PACKAGING REQUIREMENTS

- A. Interior Building Luminaires:
 - 1. Lighting Control System shall be provided as separate bid package from luminaires.
 - 2. It is recommended that the building lighting be considered as up to (2) packages of luminaires to allow for competitive pricing. Coordinate with lighting designer on packaging guidance recommendations.
- B. Site Lighting
 - 1. Site luminaires shall be provided as a separate bid package from the building mounted exterior luminaires.

Image:



Detail:



AD01A

3" Round Downlight

Description

3" Downlight Static White

Physical Requirements

Dimensions: 3.15" D x 5.25"W x 9.35" L x 2.75" H

Construction: Standard NIC Housing

Optic: 60deg optic

Finish: White, Per Architect

Mounting: Ceiling, Recessed

Listing: UL Damp

Location: Bunk Rooms

Luminaire Performance Criteria

Lumen Output: 825 lm Static White LED

CCT: 3000K

CRI: 90+

Life: 50,000 hr L70

Electrical Requirements

Load: 9 W

Voltage: Primary: 120/277V Universal Secondary:

Driver: Remodel Driver

Control: 0-10v Dimming to 1%

Basis Of Design

Manufacturer: Lightheaded

Model: Opus Eco

Model Number: E3RF-T_-01-00-OPEN-B60-30-9008-_-P-UNV-_-CL/
SL-F

Alternates

Alternate 1: Lumenwerx LIVV PLUS 3.5" DOWNLIGHT

Alternate 2: Prescolite

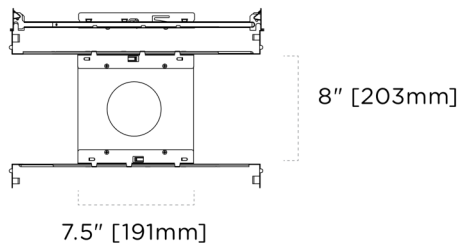
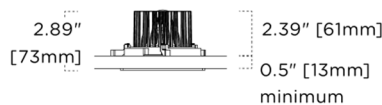
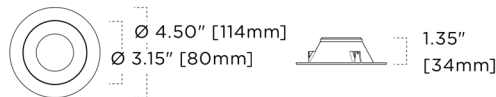
Notes:

Coordinate driver type with lighting control system for full range dimming performance. Coordinate ceiling thickness with architectural RCP and ceiling type. Provide softening lens SL as alternate media for in-field adjustment.

Image:



Detail:



AD01B

3" Round Downlight

Description

3" Downlight Static White

Physical Requirements

Dimensions: 3.15" D x 5.25"W x 9.35" L x 2.75" H

Construction: Standard NIC Housing

Optic: 80deg optic

Finish: White, Per Architect

Mounting: Ceiling, Recessed

Listing: UL Damp

Location: Varies

Luminaire Performance Criteria

Lumen Output: 825 lm Static White LED

CCT: 3500K

CRI: 90+

Life: 50,000 hr L70

Electrical Requirements

Load: 9 W

Voltage: Primary: 120/277V Universal Secondary:

Driver: Remodel Driver

Control: 0-10v Dimming to 1%

Basis Of Design

Manufacturer: Lightheaded

Model: Opus Eco

Model Number: E3RF-T_-01-00-OPEN-B80-35-9008-_-P-UNV-_-CL/
SL-F

Alternates

Alternate 1: Lumenwerx LIVV PLUS 3.5" DOWNLIGHT

Alternate 2: Prescolite

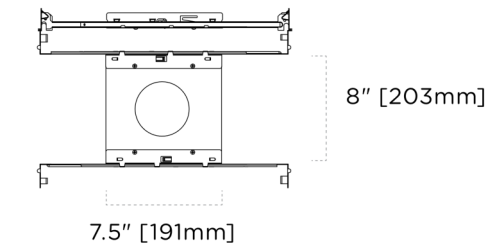
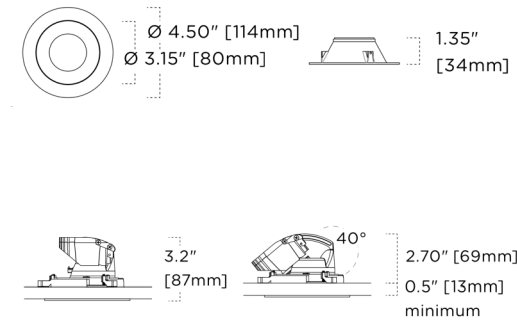
Notes:

Coordinate driver type with lighting control system for full range dimming performance. Coordinate ceiling thickness with architectural RCP and ceiling type. Provide softening lens SL as alternate media for in-field adjustment.

Image:



Detail:



AD01C

3" Round Downlight

Description

3" Adjustable Downlight Static White

Physical Requirements

Dimensions: 3.15" D x 5.25"W x 9.35" L x 2.75" H

Construction: Standard NIC Housing

Optic: 20deg optic

Finish: White, Per Architect

Mounting: Ceiling, Recessed

Listing: UL Damp

Location: Kitchen

Luminaire Performance Criteria

Lumen Output: 825 lm Static White LED

CCT: 3500K

CRI: 90+

Life: 50,000 hr L70

Electrical Requirements

Load: 9 W

Voltage: Primary: 120/277V Universal Secondary:

Driver: Remodel Driver

Control: 0-10v Dimming to 1%

Basis Of Design

Manufacturer: Lightheaded

Model: Opus Eco

Model Number: E3RA-T_-01-00-OPEN-B20-35-9008-_P-UNV-_CL/
SL-F

Alternates

Alternate 1: Lumenwerx LIVV PLUS 3.5" DOWNLIGHT

Alternate 2: Prescolite

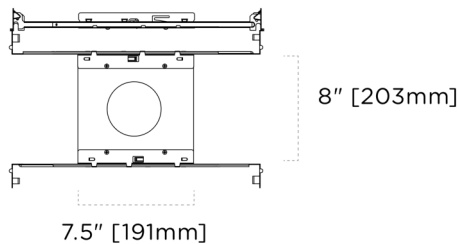
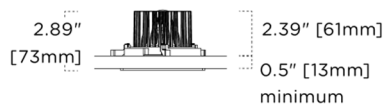
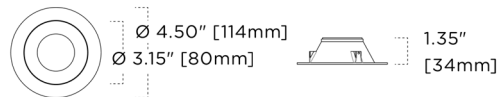
Notes:

Coordinate driver type with lighting control system for full range dimming performance. Coordinate ceiling thickness with architectural RCP and ceiling type. Provide softening lens SL as alternate media for in-field adjustment.

Image:



Detail:



AD02A

3" Round Downlight

Description

3" Downlight Tunable White

Physical Requirements

Dimensions: 3.15" D x 5.25"W x 9.35" L x 2.75" H

Construction: Standard NIC Housing

Optic: 60deg optic

Finish: White, Per Architect

Mounting: Ceiling, Recessed

Listing: UL Damp

Location: Corridors

Luminaire Performance Criteria

Lumen Output: 780 lm Dynamic White LED

CCT: 2700K - 4000K

CRI: 90+

Life: 50,000 hr L70

Electrical Requirements

Load: 9 W

Voltage: Primary: 120/277V Universal Secondary:

Driver: Remodel Driver

Control: 0-10v Dimming to 1%

Basis Of Design

Manufacturer: Lightheaded

Model: Opus Eco

Model Number: E3RF-T_-01-00-OPEN-B60-
4018TW-9208-_-P-UNV-_-CL/
SL-F

Alternates

Alternate 1: Lumenwerx LIVV PLUS 3.5" DOWNLIGHT

Alternate 2: Prescolite

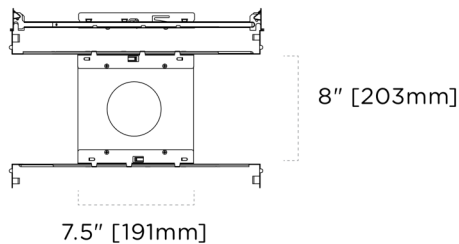
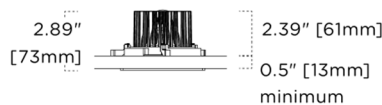
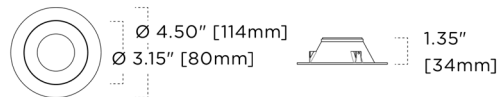
Notes:

Coordinate driver type with lighting control system for full range dimming performance. Coordinate ceiling thickness with architectural RCP and ceiling type. Provide softening lens SL as alternate media for in-field adjustment.

Image:



Detail:



AD02B

3" Round Downlight

Description

3" Downlight Tunable White Higher Output

Physical Requirements

Dimensions: 3.15" D x 5.25"W x 9.35" L x 2.75" H
Construction: Standard NIC Housing
Optic: 60deg optic
Finish: White, Per Architect
Mounting: Ceiling, Recessed
Listing: UL Damp
Location: Corridors

Luminaire Performance Criteria

Lumen Output: 1050 lm Dynamic White LED
CCT: 2700K - 4000K
CRI: 90+
Life: 50,000 hr L70

Electrical Requirements

Load: 13 W
Voltage: Primary: 120/277V Universal Secondary:
Driver: Remodel Driver
Control: 0-10v Dimming to 1%

Basis Of Design

Manufacturer: Lightheaded
Model: Opus Eco
Model Number: E3RF-T_-01-00-OPEN-B60-4018TW-9210_-P-UNV_-CL/SL-F

Alternates

Alternate 1: Lumenwerx LIVV PLUS 3.5" DOWNLIGHT
Alternate 2: Prescolite

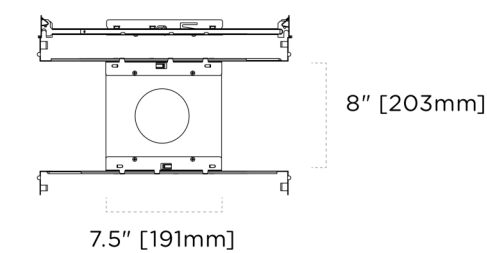
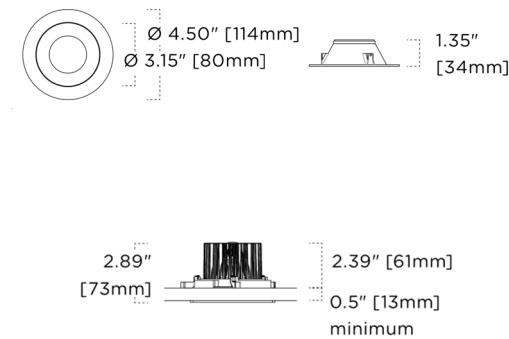
Notes:

Coordinate driver type with lighting control system for full range dimming performance. Coordinate ceiling thickness with architectural RCP and ceiling type. Provide softening lens SL as alternate media for in-field adjustment.

Image:



Detail:



AD02C

3" Round Downlight

Description

3" Downlight Tunable White

Physical Requirements

Dimensions: 3.15" D x 5.25"W x 9.35" L x 2.75" H
Construction: Standard NIC Housing
Optic: 20deg optic
Finish: White, Per Architect
Mounting: Ceiling, Recessed
Listing: UL Damp
Location: Niches

Luminaire Performance Criteria

Lumen Output: 780 lm Dynamic White LED
CCT: 2700K - 4000K
CRI: 90+
Life: 50,000 hr L70

Electrical Requirements

Load: 9 W
Voltage: Primary: 120/277V Universal Secondary:
Driver: Remodel Driver
Control: 0-10v Dimming to 1%

Basis Of Design

Manufacturer: Lightheaded
Model: Opus Eco
Model Number: E3RF-T_-01-00-OPEN-B20-4018TW-9208-_-P-UNV-_-CL/SL-F

Alternates

Alternate 1: Lumenwerx LIVV PLUS 3.5" DOWNLIGHT
Alternate 2: Prescolite

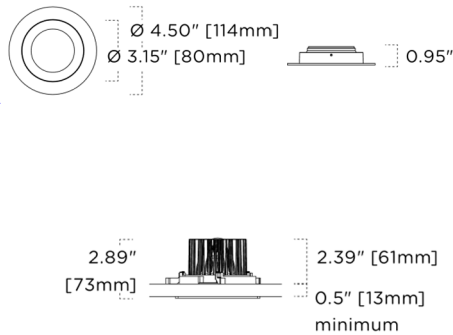
Notes:

Coordinate driver type with lighting control system for full range dimming performance. Coordinate ceiling thickness with architectural RCP and ceiling type. Provide softening lens SL as alternate media for in-field adjustment.

Image:



Detail:



AD04A

3” Round Downlight

Description

3” Downlight Wet Locations

Physical Requirements

Dimensions: 3.15” D x 5.25”W x 9.35” L x 2.75” H
Construction: Dead-front Trim, IC shallow housing
Optic: Regressed frosted glass lens, 80deg optic
Finish: Per Architect
Mounting: Ceiling, Recessed
Listing: UL Wet
Location: Showers

Luminaire Performance Criteria

Lumen Output: 825 lm Static White LED
CCT: 3500K
CRI: 90+
Life: 50,000 hr L70

Electrical Requirements

Load: 9 W
Voltage: Primary: 120/277V Universal Secondary:
Driver: Remodel Driver
Control: 0-10v Dimming to 1%

Basis Of Design

Manufacturer: Lightheaded
Model: Opus Eco
Model Number: E3RYA-T-CL-01-00-GFRO-B80-35-9008-_-P-UNV-_-_-SIC

Alternates

Alternate 1: Lumenwerx LIVV PLUS 3.5” DOWNLIGHT
Alternate 2: Prescolite

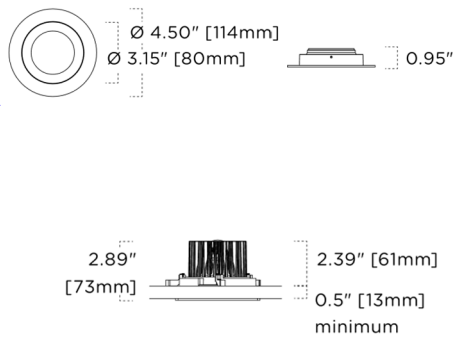
Notes:

Coordinate driver type with lighting control system for full range dimming performance. Coordinate ceiling thickness with architectural RCP and ceiling type.

Image:



Detail:



AD04B

3” Round Downlight

Description

3” Downlight Wet Locations

Physical Requirements

Dimensions: 3.15” D x 5.25”W x 9.35” L x 2.75” H
Construction: Dead-front Trim, IC shallow housing
Optic: Regressed frosted glass lens, 80deg optic
Finish: Per Architect
Mounting: Ceiling, Recessed
Listing: UL Wet
Location: Showers

Luminaire Performance Criteria

Lumen Output: 825 lm Static White LED
CCT: 4000K
CRI: 90+
Life: 50,000 hr L70

Electrical Requirements

Load: 9 W
Voltage: Primary: 120/277V Universal Secondary:
Driver: Remodel Driver
Control: 0-10v Dimming to 1%

Basis Of Design

Manufacturer: Lightheaded
Model: Opus Eco
Model Number: E3RYA-T-CL-01-00-GFRO-B80-40-9008-_-P-UNV-_-_-SIC

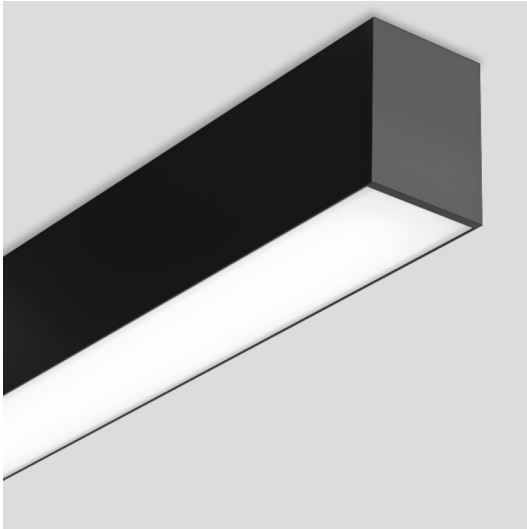
Alternates

Alternate 1: Lumenwerx LIVV PLUS 3.5” DOWNLIGHT
Alternate 2: Prescolite

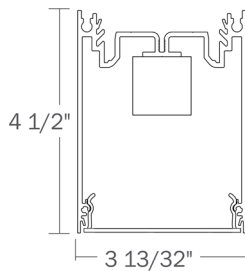
Notes:

Coordinate driver type with lighting control system for full range dimming performance. Coordinate ceiling thickness with architectural RCP and ceiling type.

Image:



Detail:



AL01

Linear LED Surface Mounted

Description

Surface mounted linear

Physical Requirements

Dimensions: 3.5" W x 4.0" H x length per plans

Construction: Extruded aluminum

Optic: Diffuse acrylic lens, continuous appearance, batwing optic

Finish: Custom Powder coated BLACK

Mounting: Ceiling, Surface

Listing: UL Damp

Location: Offices, Training Room, Exercise Room

Luminaire Performance Criteria

Lumen Output: 500 lm/ft Static White LED

CCT: 3500K

CRI: 90+

Life: 50,000 hr L70

Electrical Requirements

Load: 4.3 W/ft

Voltage: Primary: 120/277V Universal Secondary:

Driver: Integral

Control: 0-10v Dimming to 1%

Basis Of Design

Manufacturer: Axis Lighting

Model: Beam 3 Surface

Model Number: TB3SLED-500-90-35-BW-SL-C-277-DP

Alternates

Alternate 1: Lumenwerx VIA 3 SURFACE

Alternate 2: Coronet

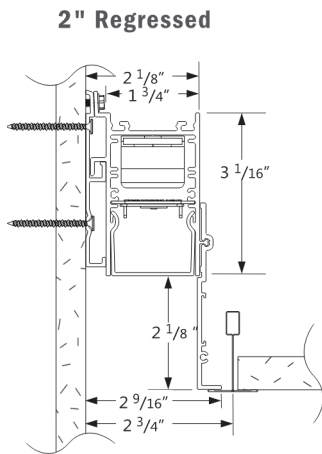
Notes:

Coordinate with ceiling type for mounting and provide all accessories for complete installation. Submit shop drawing for all linear runs.

Image:



Detail:



AL02
Linear LED Perimeter

Description

Perimeter Linear 2" regressed

Physical Requirements

Dimensions: 3 1/16" H x 2 1/8" W x length per plans
Construction: Extruded aluminum
Optic: Diffusing continuous lens
Finish: Custom Powder coated WHITE
Mounting: Ceiling, Recessed
Listing: UL Damp
Location: Restrooms

Luminaire Performance Criteria

Lumen Output: 300 lm/ft Static White LED
CCT: 3500K
CRI: 90+
Life: 50,000 hr L70

Electrical Requirements

Load: 3.5 W/ft
Voltage: Primary: 120/277V Universal Secondary:
Driver: Integral
Control: 0-10v Dimming to 1%

Basis Of Design

Manufacturer: Axis Lighting
Model: Sculpt Linear Perimeter Recessed
Model Number: SCPLD-300-90-35-RG2-SL-C-UNV-DP

Alternates

Alternate 1: Lumenwerx VIA 2 PERIMETER
Alternate 2: Coronet

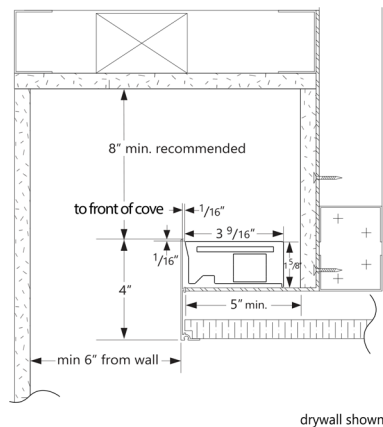
Notes:

Coordinate with ceiling type for mounting and provide all accessories for complete installation. Submit shop drawing for all linear runs.

Image:



Detail:



AL03
Linear LED Perimeter

Description

Indirect cove luminaire

Physical Requirements

Dimensions: 1 5/8" L x 3 9/16" W x length per plans
Construction: Extruded aluminum
Optic: Diffusing continuous lens
Finish: Per Architect
Mounting: Cove
Listing: UL Damp
Location: Corridors

Luminaire Performance Criteria

Lumen Output: 400 lm/ft Dynamic White LED
CCT: 2700K - 4000K
CRI: 90+
Life: 50,000 hr L70

Electrical Requirements

Load: 3.5 W/ft
Voltage: Primary: 120/277V Universal Secondary:
Driver: Integral
Control: 0-10v Dimming to 1%

Basis Of Design

Manufacturer: Axis Lighting
Model: Cove Perfekt (wall)
Model Number: CCW-L-O-_-400-90-TW2750-W-277-TW-_-C

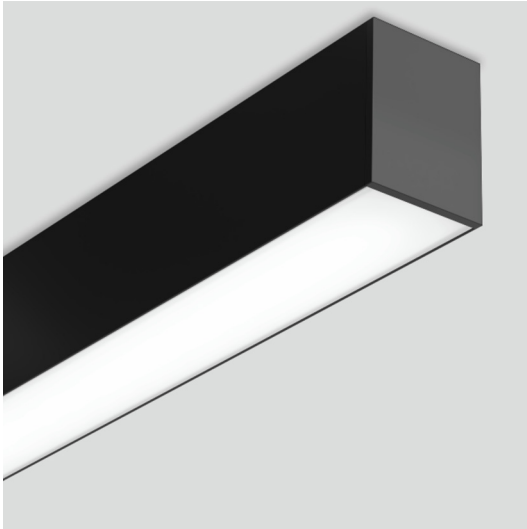
Alternates

Alternate 1: Lumenwerx EVOQ COMPONENTS COVE
Alternate 2: Coronet

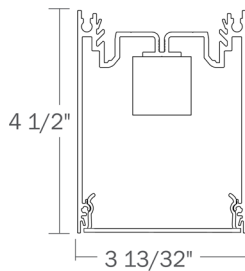
Notes:

Coordinate with ceiling type for mounting and provide all accessories for complete installation. Submit shop drawing for all linear runs.

Image:



Detail:



AL05

Linear LED Surface Mounted

Description

Surface mounted linear

Physical Requirements

Dimensions: 3.5" W x 4.0" H x length per plans

Construction: Extruded aluminum

Optic: Diffuse acrylic lens, continuous appearance, batwing optic

Finish: Custom Powder coated BLACK

Mounting: Ceiling, Surface

Listing: UL Damp

Location: Watch Room

Luminaire Performance Criteria

Lumen Output: 1000 lm/ft Dynamic White LED

CCT: 2700K - 4000K

CRI: 90+

Life: 50,000 hr L70

Electrical Requirements

Load: 9.3 W/ft

Voltage: Primary: 120/277V Universal Secondary:

Driver: Integral

Control: 0-10v Dimming to 1%

Basis Of Design

Manufacturer: Axis Lighting

Model: Beam 3 Surface

Model Number: TB3SLED-1000-90-TW2750-BW-SL-C-277-TW

Alternates

Alternate 1: Lumenwerx VIA 3 SURFACE

Alternate 2: Coronet

Notes:

Coordinate with ceiling type for mounting and provide all accessories for complete installation. Submit shop drawing for all linear runs.

Image:



Detail:

AL06

LED Tape Light

Description

Tape Light 3000K

Physical Requirements

Dimensions: 0.42"H x .93"W x length per plans

Construction: Extruded aluminum Channel

Optic: Diffuse acrylic lens

Finish: White

Mounting: Ceiling, Surface

Listing: UL Damp

Location: Dayroom and Kitchen

Luminaire Performance Criteria

Lumen Output: 657lm/ft Static White LED

CCT: 3000K

CRI: 90+

Life: 50,000 hr L70

Electrical Requirements

Load: 6 W/ft

Voltage: Primary: 120/277V Universal Secondary:

Driver: Remote

Control: 0-10v Dimming to 1%

Basis Of Design

Manufacturer: Acolyte

Model: AS3

Model Number: CHAS3-F-WH-RB-90-SWS220-6.0-30-3

Alternates

Alternate 1: LEDscape Lighting LENGTH-FLEX

Alternate 2: Led Linear

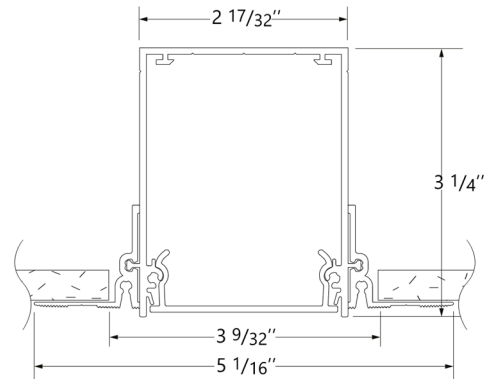
Notes:

Coordinate remote driver and channel mounting and provide all accessories for complete installation.

Image:



Detail:



AL07

Linear LED Recessed

Description

2" Recessed Linear

Physical Requirements

Dimensions: 3 1/4"H x 3 1/16" W x length per plans
Construction: Extruded aluminum, IC Rated
Optic: Diffuse acrylic lens, continuous appearance
Finish: White
Mounting: Ceiling, Recessed
Listing: UL Damp
Location: Niches

Luminaire Performance Criteria

Lumen Output: 300 lm/ft Static White LED
CCT: 3500K
CRI: 90+
Life: 50,000 hr L70

Electrical Requirements

Load: 4 W/ft
Voltage: Primary: 120/277V Universal Secondary:
Driver: Integral
Control: 0-10v Dimming to 1%

Basis Of Design

Manufacturer: Axis Lighting
Model: Beam 2 Recessed
Model Number: B2SQRLLED-300-90-35-SO-SL-W-UNV-DP-DS

Alternates

Alternate 1: Lumenwerx VIA 2 RECESSED
Alternate 2: Coronet

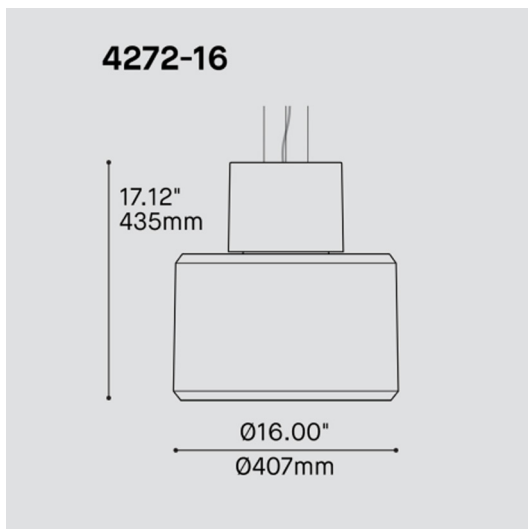
Notes:

Coordinate with ceiling type for mounting and provide all accessories for complete installation. Submit shop drawing for all linear runs.

Image:



Detail:



AP01

Round Pendant

Description

Decorative Pendant Light 16" Diameter Direct Only 2700K

Physical Requirements

Dimensions: 16" Diam x 17" H
Construction: Die form aluminum
Optic: Round Diffuser
Finish: Black
Mounting: Ceiling, Suspended
Listing: UL Damp
Location: Kitchen

Luminaire Performance Criteria

Lumen Output: 2620 lm Static White LED
CCT: 2700K
CRI: 90+
Life: 50,000 hr L70

Electrical Requirements

Load: 35 W
Voltage: Primary: 120/277V Universal Secondary:
Driver: Integral
Control: 0-10v Dimming to 1%

Basis Of Design

Manufacturer: Eureka
Model: Stella 4272
Model Number: 4272D-16-27-90-277V-DV-S10-**-BLKE-BLK-BLKE-WH

Alternates

Alternate 1: or equal approved by Interior Designer
Alternate 2: or equal approved by Interior Designer

Notes:

Coordinate with ceiling type for mounting and provide all accessories for complete installation. Length of stem to be coordinated with the Architect

Image:



Detail:

AP02

Cylinder Pendant

Description

2.5" Cylinder Suspended stem drookit 3000K

Physical Requirements

Dimensions: 2.5" Diam x 5.92" H x length of stem

Construction: Die form aluminum

Optic: Regressed softening lens, 60deg optic

Finish: Black Powder coat

Mounting: Ceiling, Suspended

Listing: UL Damp

Location: Kitchen

Luminaire Performance Criteria

Lumen Output: 952 lm Static White LED

CCT: 3000K

CRI: 90+

Life: 50,000 hr L70

Electrical Requirements

Load: 11 W

Voltage: Primary: 120/277V Universal Secondary:

Driver: Integral

Control: 0-10v Dimming to 1%

Basis Of Design

Manufacturer: Lucifer Lighting

Model: CD1X

Model Number: CD1X-172-FB-1-BL-BL-90S-11A-30-60-4-2-UCA-JBMP-

Alternates

Alternate 1: Sistemalux

Alternate 2: Prescolite

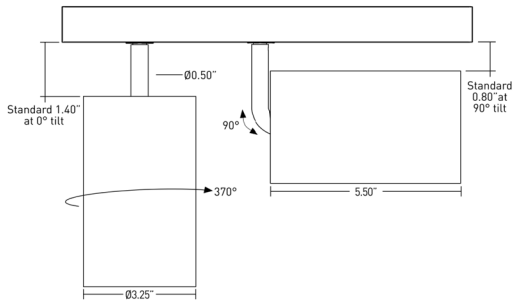
Notes:

Coordinate with ceiling type for mounting and provide all accessories for complete installation.

Image:



Detail:



ATH01A

3" Round Track head

Description

3" Round track head monopoint adjustable

Physical Requirements

Dimensions: 3.15" D x 5.25"W x 9.35" L x 2.75" H
Construction: Standard NIC Housing
Optic: 40deg optic
Finish: Black Powder coat
Mounting: Track
Listing: UL Damp
Location: Kitchen

Luminaire Performance Criteria

Lumen Output: 1045lm Static White LED
CCT: 3500K
CRI: 90+
Life: 50,000 hr L70

Electrical Requirements

Load: 11 W
Voltage: Primary: 120V Secondary:
Driver: Integral
Control: ELV/TRIAC Dimming to 2%

Basis Of Design

Manufacturer: Lucifer Lighting
Model: CTM2
Model Number: CTM2-A-04-1-CF-CF-CF-CF-90S11A-35-40-CE3

Alternates

Alternate 1: LSI LX2020
Alternate 2: Coronet

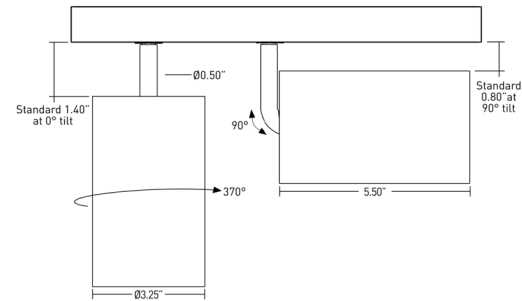
Notes:

For use with AT01 series track. Coordinate ceiling mounting requirements and all accessories for complete installation. Coordinate with lighting control system. Provide with Sot Focus Lens and Honeycomb Louver. Provide additional Frosted linear Spread Lens

Image:



Detail:



ATH01B

3" Round Track head

Description

3" Round track head monopoint adjustable

Physical Requirements

Dimensions: 3.15" D x 5.25"W x 9.35" L x 2.75" H

Construction: Standard NIC Housing

Optic: 40deg optic

Finish: Black Powder coat

Mounting: Track

Listing: UL Damp

Location: Kitchen

Luminaire Performance Criteria

Lumen Output: 1045lm Static White LED

CCT: 3000K

CRI: 90+

Life: 50,000 hr L70

Electrical Requirements

Load: 11 W

Voltage: Primary: 120V Secondary:

Driver: Integral

Control: ELV/TRIAC Dimming to 2%

Basis Of Design

Manufacturer: Lucifer Lighting

Model: CTM2

Model Number: CTM2-A-04-1-CF-CF-CF-CF-90S11A-30-40-CE3

Alternates

Alternate 1: LSI LX2020

Alternate 2: Coronet

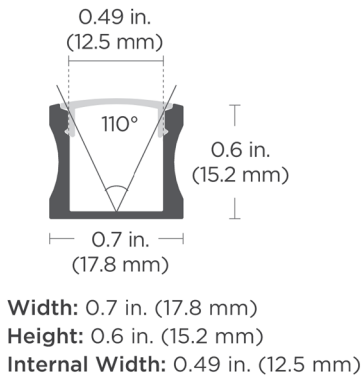
Notes:

For use with AT01 series track. Coordinate ceiling mounting requirements and all accessories for complete installation. Coordinate with lighting control system. Provide with Sot Focus Lens and Honeycomb Louver.

Image:



Detail:



AW01
LED Tape Light

Description

Tape Light Warm Dim 2900K-2000K

Physical Requirements

Dimensions: 0.42”H x .93”W x length per plans (custom)
Construction: Extruded aluminum Channel
Optic: Diffuse acrylic lens
Finish: White
Mounting: Ceiling, Surface
Listing: UL Damp
Location: Bunk Rooms

Luminaire Performance Criteria

Lumen Output: 244lm/ft Warm dim LED
CCT: 2900K-2000K
CRI: 90+
Life: 50,000 hr L70

Electrical Requirements

Load: 5.2 W/ft
Voltage: Primary: 120/277V Universal Secondary:
Driver: Remote
Control: 0-10v Dimming to 1%

Basis Of Design

Manufacturer: Acolyte
Model: AS2
Model Number: CHAS2-FWH-RB-90-WD20--5.2-2920-1

Alternates

Alternate 1: LEDscape Lighting LENGTH-FLEX
Alternate 2: Led Linear

Notes:

Coordinate remote driver and channel mounting and provide all accessories for complete installation.

Image:



Detail:

AW02

Task Light

Description

Wall mount task light

Physical Requirements

Dimensions: 3.7"H x 3.7"W x 6.3"L (or depth)

Construction: Die form aluminum

Optic: Opal Diffuser

Finish: Black

Mounting: Wall, Surface

Listing: UL Damp

Location: Bunk Rooms

Luminaire Performance Criteria

Lumen Output: 220 lm Static White LED

CCT: 2700K

CRI: 90+

Life: 50,000 hr L70

Electrical Requirements

Load: 8 W

Voltage: Primary: 120V Secondary:

Driver: Integral

Control: Integral Dimmer Switch

Basis Of Design

Manufacturer: Muuto

Model: Tip Wall Lamp

Model Number:

Alternates

Alternate 1: or equal approved by Interior Designer

Alternate 2: or equal approved by Interior Designer

Notes:

Image:



Detail:

AW03

Wall Mounted Linear

Description

Wall mount Linear light for stair with Integral Occ Sensor

Physical Requirements

Dimensions: 4 1/2"H x 3 3/8"W x length per plans
Construction: Die form aluminum
Optic: Opal Diffuser
Finish: Custom Powder coated BLACK
Mounting: Wall, Surface
Listing: UL Damp
Location: Stairs

Luminaire Performance Criteria

Lumen Output: 1100 lm/ft Static White LED
CCT: 4000K
CRI: 90+
Life: 50,000 hr L70

Electrical Requirements

Load: 8.8 W/ft
Voltage: Primary: 120/277V Universal Secondary:
Driver: Integral
Control: 0-10v Dimming to 1%

Basis Of Design

Manufacturer: Axis Lighting
Model: Beam 3 Wall mounted
Model Number: TB3WDLED-110-90-40-SO-SL-C-UNV-DP-OS

Alternates

Alternate 1: Lumenwerx
Alternate 2: Coronet

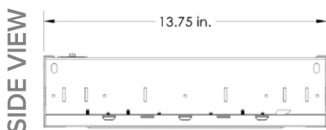
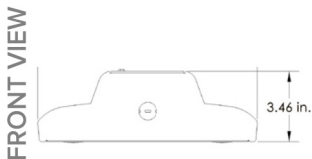
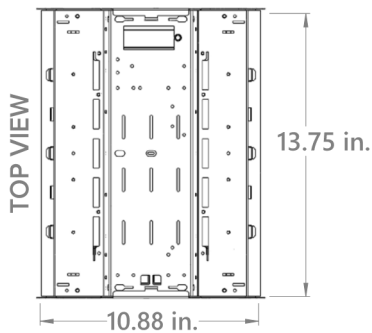
Notes:

Provide with IC control (OS) Occupancy Sensor integrated.

Image:



Detail:



FP01
High Bay LED

Description

High Bay LED Indirect-Direct Pendant

Physical Requirements

Dimensions: 13.75" L x 10.88" W x 3.46" H
Construction: Die form aluminum
Optic: Indirect - Direct Diffuse Optic Wide
Finish: Custom Black
Mounting: Ceiling, Suspended
Listing: UL Damp
Location:

Luminaire Performance Criteria

Lumen Output: 18000 lm Static White LED
CCT: 830 3000K Indirect- 840 4000K Direct
CRI: 80+
Life: 50,000 hr L70

Electrical Requirements

Load: 138 W
Voltage: Primary: 120/277V Universal Secondary:
Driver: Integral
Control: 0-10v Dimming

Basis Of Design

Manufacturer: Columbia Lighting
Model: Echelan
Model Number: ECH1-940-L18-DW-ED-277-PM-U4

Alternates

Alternate 1: ILP EDV2
Alternate 2: Zumbobel

Notes:

Coordinate with ceiling type for mounting and provide all accessories for complete installation. Provide with U4 uplight separately controlled, 3000K. Provide with Custom finish BLACK

Image:



Detail:

FP02
LED Strip

Description

LED Strip Round Lens Pendant Mounted

Physical Requirements

Dimensions: 48.06”L x 3”W x 2.44”H
Construction: Code-gauge steel
Optic: Wide distribution
Finish: Per Architect
Mounting: Wall, Surface
Listing: UL Damp
Location: Varies

Luminaire Performance Criteria

Lumen Output: 2603 lm Static White LED
CCT: 4000K
CRI: 80+
Life: 50,000 hr L70

Electrical Requirements

Load: 4 W/ft
Voltage: Primary: 120/277V Universal Secondary:
Driver: Integral
Control: 0-10v Dimming

Basis Of Design

Manufacturer: Columbia Lighting
Model: MPS
Model Number: MPS-4-40-XW-C-W-ED-U

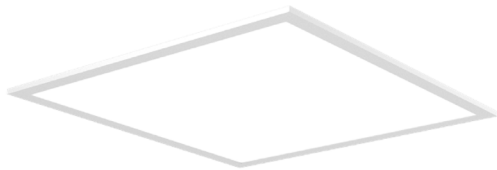
Alternates

Alternate 1: ILP Discovery Linear Strip
Alternate 2: Leviton

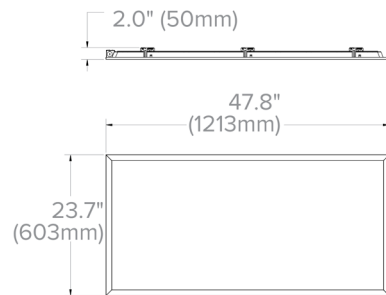
Notes:

Provide all accessories for complete suspended installation.

Image:



Detail:



FR01A

Troffer

Description

2X4 Troffer

Physical Requirements

Dimensions: 23.7"L x 47.8"W x 2.0"H

Construction: Code-gauge steel

Optic: Diffuse

Finish: Per Architect

Mounting: Ceiling, Recessed, Surface

Listing: UL Damp

Location: Varies

Luminaire Performance Criteria

Lumen Output: 3564 lm Static White LED

CCT: 4000K

CRI: 80+

Life: 50,000 hr L70

Electrical Requirements

Load: 25 W

Voltage: Primary: 120/277V Universal Secondary:

Driver: Integral

Control: 0-10v Dimming

Basis Of Design

Manufacturer: Columbia Lighting

Model: CBT LSCS

Model Number: CBT-24B-LSCS-EDD

Alternates

Alternate 1: ILP VPAN

Alternate 2: Leviton

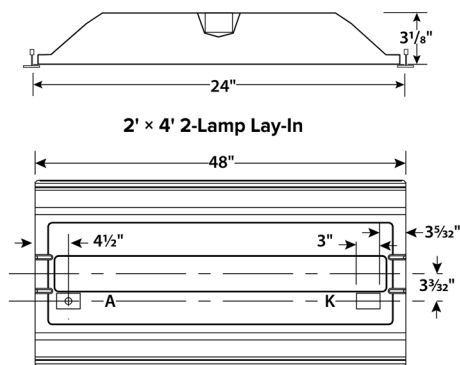
Notes:

Coordinate with ceiling type for mounting and provide all accessories for complete installation. For gypsum ceilings, supply a 2x4 Surface Mount kit (PSMK24)

Image:



Detail:



FR01B

Troffer

Description

2X4 Troffer Wet Listed

Physical Requirements

Dimensions: 48"L x 24" W x 3 1/8"H
Construction: Code-gauge steel
Optic: Acrylic Lens
Finish: Per Architect
Mounting: Ceiling, Recessed
Listing: UL Wet
Location: Varies

Luminaire Performance Criteria

Lumen Output: 3495 lm Static White LED
CCT: 4000K
CRI: 80+
Life: 50,000 hr L70

Electrical Requirements

Load: 27 W
Voltage: Primary: 120/277V Universal Secondary:
Driver: Integral
Control: 0-10v Dimming

Basis Of Design

Manufacturer: Columbia Lighting
Model: LJT24
Model Number: LJT24-40-VW-G-FS-A12-ED-U

Alternates

Alternate 1: Lithonia Lighting CPXIP
Alternate 2: Leviton

Notes:

Coordinate with ceiling type for mounting and provide all accessories for complete installation.

Image:



Detail:

FS01

LED Strip

Description

LED Strip Round Lens Surface Mounted

Physical Requirements

Dimensions: 48.06"L x 3"W x 2.44"H
Construction: Code-gauge steel
Optic: Wide distribution
Finish: Per Architect
Mounting: Ceiling, Surface
Listing: UL Damp
Location: Varies

Luminaire Performance Criteria

Lumen Output: 2603 lm Static White LED
CCT: 4000K
CRI: 80+
Life: 50,000 hr L70

Electrical Requirements

Load: 4 W/ft
Voltage: Primary: 120/277V Universal Secondary:
Driver: Integral
Control: 0-10v Dimming

Basis Of Design

Manufacturer: Columbia Lighting
Model: MPS
Model Number: MPS-4-40-XW-C-W-ED-U

Alternates

Alternate 1: ILP Discovery Linear Strip
Alternate 2: Leviton

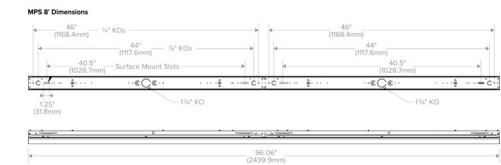
Notes:

Provide all accessories for complete surface installation.

Image:



Detail:



FW01 LED Strip

Description

LED Strip Flat Lens Wall Mounted

Physical Requirements

Dimensions: 96.06"L x 3"W x 2.44"H

Construction: Code-gauge steel

Optic: Wide distribution

Finish: Matte Black

Mounting: Wall, Surface

Listing: UL Damp

Location: Staircase

Luminaire Performance Criteria

Lumen Output: 902 lm/ft Static White LED

CCT: 4000K

CRI: 80+

Life: 50,000 hr L70

Electrical Requirements

Load: 5.75 W/ft

Voltage: Primary: 120/277V Universal Secondary:

Driver: Integral

Control: 0-10v Dimming

Basis Of Design

Manufacturer: Columbia Lighting

Model: MPS

Model Number: MPS-8-40-MW-F-W-ED-U-MB

Alternates

Alternate 1: ILP Discovery Linear Strip

Alternate 2: Leviton

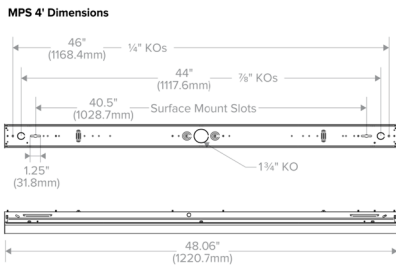
Notes:

Provide all accessories for complete wall installation. Provide with Occupancy Sensor integrated, ensuring compatibility with Lighting control system

Image:



Detail:



FW02 LED Strip

Description

LED Strip Round Lens Wall Mounted Elevator Pit

Physical Requirements

Dimensions: 48.06"L x 3"W x 2.44"H

Construction: Code-gauge steel

Optic: Wide distribution

Finish: Per Architect

Mounting: Wall, Surface

Listing: UL Damp

Location: Elevator Pit

Luminaire Performance Criteria

Lumen Output: 2603 lm Static White LED

CCT: 4000K

CRI: 80+

Life: 50,000 hr L70

Electrical Requirements

Load: 4 W/ft

Voltage: Primary: 120/277V Universal Secondary:

Driver: Integral

Control: 0-10v Dimming

Basis Of Design

Manufacturer: Columbia Lighting

Model: MPS

Model Number: MPS-4-40-XW-C-W-ED-U

Alternates

Alternate 1: ILP Discovery Linear Strip

Alternate 2: Leviton

Notes:

Provide all accessories for complete wall installation.

Image:



Detail:

FW03

Wall Mounted

Description

LED Wall Mounted For Training Tower

Physical Requirements

Dimensions: 47 1/4"L x 5 5/16"W x 3 1/2"H

Construction: Extruded aluminum

Optic: Full Diffusion

Finish: Per Architect

Mounting: Wall, Surface

Listing: IP65

Location: Training Tower

Luminaire Performance Criteria

Lumen Output: 3500 lm Static White LED

CCT: 4000K

CRI: 80+

Life: 50,000 hr L70

Electrical Requirements

Load: 26 W

Voltage: Primary: 120/277V Universal Secondary:

Driver: Integral

Control: 0-10v Dimming

Basis Of Design

Manufacturer: Leviton

Model: VRSE-5

Model Number: VRSE5-48RC-LED840K035LUNV-DFP-X8

Alternates

Alternate 1: New Star STARTRANS

Alternate 2: Columbia

Notes:

Provide all accessories for complete wall installation.

Image:



Detail:

PS01

Purvis System LED

Description

Purvis System LED Light Red Ceiling and Wall Mounted

Physical Requirements

Dimensions: 13"D x 3 1/4" H

Construction:

Optic:

Finish: Per Architect

Mounting: Ceiling, Wall Recessed

Listing:

Location:

Luminaire Performance Criteria

Lumen Output: RGBW LED

CCT: Red

CRI:

Life:

Electrical Requirements

Load: 4 W

Voltage: Primary: 120V Secondary:

Driver:

Control:

Basis Of Design

Manufacturer: Purvis Systems

Model: Bogen 8-inch Recessed Speaker

Model Number:

Alternates

Alternate 1:

Alternate 2:

Notes:

Image:



Detail:

PS02

Purvis System Strobe

Description

Purvis System Strobe Light Red Wall Mounted

Physical Requirements

Dimensions: 4.5"L x 2.75"W x 2.9"H

Construction:

Optic:

Finish: Per Architect

Mounting: Wall, Recessed

Listing:

Location:

Luminaire Performance Criteria

Lumen Output: RGBW LED

CCT: Red

CRI:

Life:

Electrical Requirements

Load: 10 W

Voltage: Primary: 120V Secondary:

Driver:

Control:

Basis Of Design

Manufacturer: Purvis Systems

Model: Red Strobe Lights

Model Number:

Alternates

Alternate 1:

Alternate 2:

Notes:

Image:



Detail:

S-G

Stop and Go Wall Mounted

Description

Stop and Go Communication Lights Wall Mounted

Physical Requirements

Dimensions: 1' 1"L x 8"W x 4"D

Construction:

Optic:

Finish: Per Architect

Mounting: Wall, Surface

Listing:

Location:

Luminaire Performance Criteria

Lumen Output: RGBW LED

CCT: Red and Green

CRI:

Life:

Electrical Requirements

Load: 20 W

Voltage: Primary: 120V Secondary:

Driver:

Control:

Basis Of Design

Manufacturer: TRI LITE

Model: RGL24LY

Model Number:

Alternates

Alternate 1:

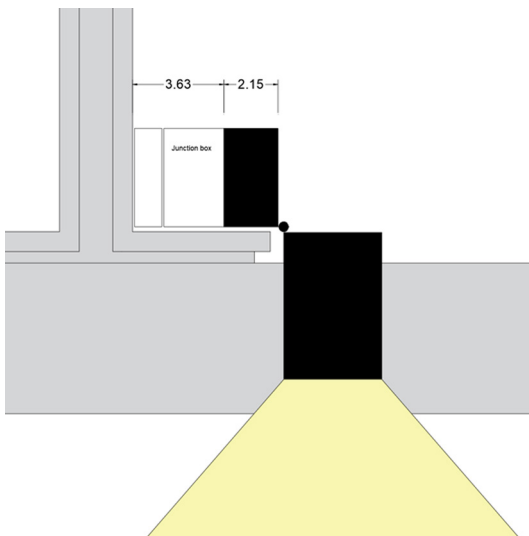
Alternate 2:

Notes:

Image:



Detail:



E01

Surface Mount Downlight

Description

3" Cylinder Surface Mount Wet Location

Physical Requirements

Dimensions: 3.91" Diam x 6.96" H

Construction: Die form aluminum

Optic: 60deg optic

Finish: Black Powder coat

Mounting: Ceiling, Surface

Listing: UL Wet

Location: Trellis Outdoor Terrace

Luminaire Performance Criteria

Lumen Output: 1060 lm Static White LED

CCT: 3000K

CRI: 90+

Life: 50,000 hr L70

Electrical Requirements

Load: 11 W

Voltage: Primary: 120/277V Universal Secondary:

Driver: Integral

Control: 0-10v Dimming

Basis Of Design

Manufacturer: Lucifer Lighting

Model: CY3X

Model Number: CY3XAD2BK BK90S11B30404UCA3-

Alternates

Alternate 1: Gotham Lighting Incito 2

Alternate 2: Prescolite

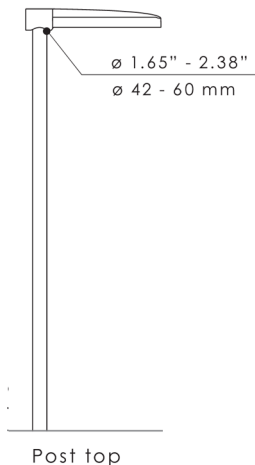
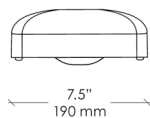
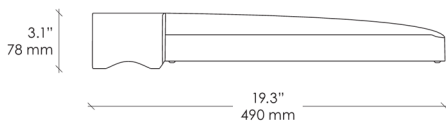
Notes:

Provide with Modified Wet-Rated CMJB: CY3X-CMJB-(BLACK)-WET-(# of conduit holes)-CPR1733, and (3)CY3X-CMJB-CF-WET-2-CPR1733 (1) CY3X-CMJB-CF-WET-1-CPR1733 for daisy chain installation

Image:



Detail:



E02A
Pole mounted Fixture

Description

Pole-top luminaire with asymmetric wide light distribution type 4

Physical Requirements

Dimensions: 19.3”L x 7.5”W x 3.1 H
Construction: Die form aluminum
Optic: Asymmetric Forward - V35
Finish: Black (RAL 9005)
Mounting: Pole mounted at 20ft
Listing: UL Wet
Location: Parking Lot

Luminaire Performance Criteria

Lumen Output: 7499 lm Static White LED
CCT: 3000K
CRI: 80+
Life: 50,000 hr L70

Electrical Requirements

Load: 70 W
Voltage: Primary: 120/277V Universal Secondary:
Driver: Integral
Control: 0-10v Dimming

Basis Of Design

Manufacturer: Vizulo
Model: Colibri Midi
Model Number: CLM-070-8-30-V35-AF-048-CB-K-A

Alternates

Alternate 1: Luminis TR900
Alternate 2: Bega

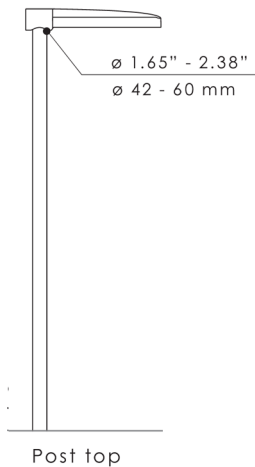
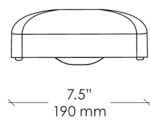
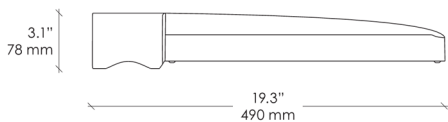
Notes:

Coordinate pole mounting detail with landscape/civil footing. Include all necessary accessories for complete installation.

Image:



Detail:



E02B
Pole mounted Fixture

Description

Pole-top luminaire with symmetric light distribution type 5

Physical Requirements

Dimensions: 19.3”L x 7.5”W x 3.1 H
Construction: Die form aluminum
Optic: Symmetric - V20
Finish: Black (RAL 9005)
Mounting: Pole mounted at 20ft
Listing: UL Wet
Location: Parking Lot

Luminaire Performance Criteria

Lumen Output: 7902 lm Static White LED
CCT: 3000K
CRI: 80+
Life: 50,000 hr L70

Electrical Requirements

Load: 70 W
Voltage: Primary: 120/277V Universal Secondary:
Driver: Integral
Control: 0-10v Dimming

Basis Of Design

Manufacturer: Vizulo
Model: Colibri Midi
Model Number: CLM-070-8-30-V20-AF-048-CB-K-A

Alternates

Alternate 1: Luminis TR900
Alternate 2: Bega

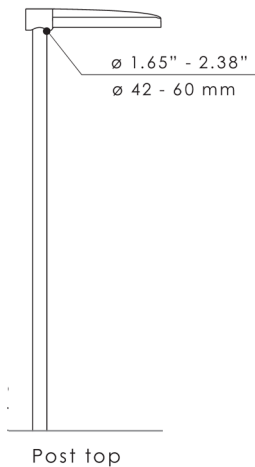
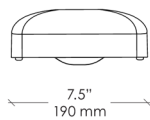
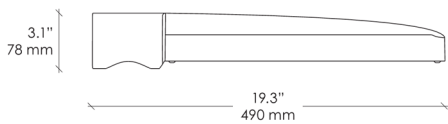
Notes:

Coordinate pole mounting detail with landscape/civil footing. Include all necessary accessories for complete installation.

Image:



Detail:



E02C
Pole mounted Fixture

Description

Pole-top luminaire with symmetric light distribution type 2

Physical Requirements

Dimensions: 19.3”L x 7.5”W x 3.1 H
Construction: Die form aluminum
Optic: Asymmetric-V05
Finish: Black (RAL 9005)
Mounting: Pole mounted at 20ft
Listing: UL Wet
Location: Parking Lot

Luminaire Performance Criteria

Lumen Output: 9266 lm Static White LED
CCT: 3000K
CRI: 80+
Life: 50,000 hr L70

Electrical Requirements

Load: 70 W
Voltage: Primary: 120/277V Universal Secondary:
Driver: Integral
Control: 0-10v Dimming

Basis Of Design

Manufacturer: Vizulo
Model: Colibri Midi
Model Number: CLM-070-8-30-V05-AF-048-CB-K-A

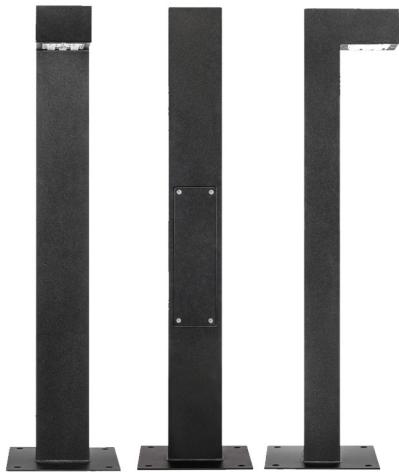
Alternates

Alternate 1: Luminis TR900
Alternate 2: Bega

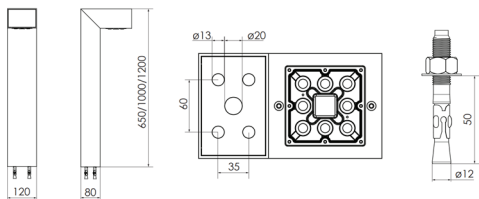
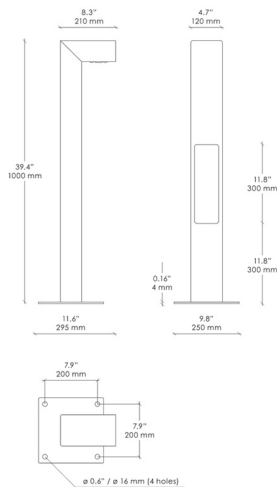
Notes:

Coordinate pole mounting detail with landscape/civil footing. Include all necessary accessories for complete installation. Provide C1 type with a rotation of the optics 90 degrees clockwise. Provide C2 type with a rotation of the optics 90 degrees counter-clockwise.

Image:



Detail:



E03

Bollard Luminaire

Description

Path Bollard

Physical Requirements

Dimensions: 39.4" H x 8.3"W x 4.7" L
Construction: Extruded aluminum and steel
Optic: E22
Finish: Black (RAL 9005)
Mounting: Ground, Surface
Listing: UL Wet
Location: Pathway Entrance

Luminaire Performance Criteria

Lumen Output: 3140 lm Static White LED
CCT: 3000K
CRI: 80+
Life: 50,000 hr L70

Electrical Requirements

Load: 26 W
Voltage: Primary: 120/277V Universal Secondary:
Driver: Integral
Control: 0-10v Dimming

Basis Of Design

Manufacturer: Vizulo
Model: Heron
Model Number: HRE-026-9-30-E22-_-008-CB-100-N-Dimming1-10

Alternates

Alternate 1: Hydrel WANDER3
Alternate 2: Bega

Notes:

Coordinate bollard mounting detail with landscape/civil footing. Include all necessary accessories for complete installation. Provide installation without flange.

Image:

E04
Not in Use

Description

Physical Requirements

Dimensions:
Construction:
Optic:
Finish:
Mounting:
Listing:
Location:

Detail:

Luminaire Performance Criteria

Lumen Output:
CCT:
CRI:
Life:

Electrical Requirements

Load:
Voltage: **Primary:** **Secondary:**
Driver:
Control:

Basis Of Design

Manufacturer:
Model:
Model Number:

Alternates

Alternate 1:

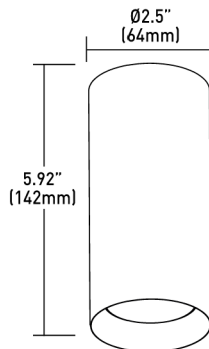
Alternate 2:

Notes:

Image:



Detail:



E05

Downlight Surface Mount

Description

3" Cylinder Fixed Surface Mounted For Canopy Wet Rated Exterior

Physical Requirements

Dimensions: 2.5" Diam x 5.92" H

Construction: Die form aluminum

Optic: 60deg optic

Finish: Custom Finish

Mounting: Ceiling, Surface

Listing: UL Wet

Location: Apparatus Bay exterior façade

Luminaire Performance Criteria

Lumen Output: 1416 lm Static White LED

CCT: 3000K

CRI: 90+

Life: 50,000 hr L70

Electrical Requirements

Load: 17 W

Voltage: Primary: 120/277V Universal Secondary:

Driver: Remote

Control: 0-10v Dimming

Basis Of Design

Manufacturer: Lucifer Lighting

Model: CY1X

Model Number: CY1X-FB-2-CF-CF-90S-17A-30-60-4-UEG-JBMP

Alternates

Alternate 1: Gotham Lighting Incito 2

Alternate 2: Prescolite

Notes:

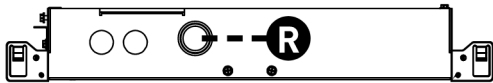
Coordinate driver type with lighting control system for full range dimming performance. Coordinate ceiling thickness with architectural RCP and ceiling type. Provide Soft Focus Lens 4 as alternate media for in-field adjustment. Fixture to mount flush with minimalist transition to ceiling.

Image:



Detail:

FIXED / WALLWASH HOUSING



E06

Recessed Downlight

Description

4" Recessed Downlight Wet Rated Exterior

Physical Requirements

Dimensions: 4.25" D x 15.50"W x 9.50" L x 2.63" H

Construction: IC housing

Optic: 85 degrees

Finish: Powder coated BLACK

Mounting: Ceiling, Recessed

Listing: UL Wet

Location: Soffit Training Tower area

Luminaire Performance Criteria

Lumen Output: 1351 lm Static White LED

CCT: 3000K

CRI: 90+

Life: 50,000 hr L70

Electrical Requirements

Load: 11 W

Voltage: Primary: 120/277V Universal Secondary:

Driver: Integral

Control: 0-10v Dimming

Basis Of Design

Manufacturer: Lucifer Lighting

Model: Fraxion4SLIM

Model Number: F4RS-2-F-BK-BK-90S-11A-30-85-07-IC-_-SG3

Alternates

Alternate 1: 3G Lighting 3G-DL45RF

Alternate 2: Prescolite

Notes:

Coordinate with ceiling type for mounting and provide all accessories for complete installation. Provide with 07 Wide Distribution Lens

Image:



Detail:

E07

Wall Mounted

Description

Wall Mounted Wet rated

Physical Requirements

Dimensions: 4.7" W x 5.9" L x 3.2" H

Construction: Extruded aluminum

Optic: E63

Finish: Black (RAL 9005)

Mounting: Wall, Surface

Listing: UL Wet

Location: Building Mounted

Luminaire Performance Criteria

Lumen Output: 3350 lm Static White LED

CCT: 3000K

CRI: 90+

Life: 50,000 hr L70

Electrical Requirements

Load: 26 W

Voltage: Primary: 120/277V Universal Secondary:

Driver: Integral

Control: 0-10v Dimming

Basis Of Design

Manufacturer: Vizulo

Model: Robin

Model Number: RBE-026-9-30--E63-008-CB-Dimming1-10

Alternates

Alternate 1: Designplan Lighting FIXED B-03

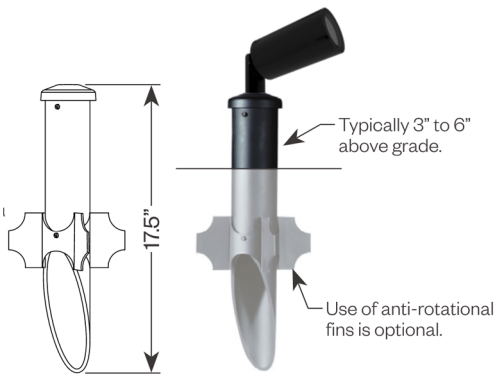
Alternate 2: Bega

Notes:

Image:



Detail:



Ground Stake (GSP-17)
(Black Polycarbonate Only)

E08
Floodlight for Flag

Description

Floodlight ground stake mounted for Flag

Physical Requirements

Dimensions: 2.7" D x 4.88"
Construction: Extruded aluminum
Optic: Medium flood 25 degrees
Finish: TBK Textured Black
Mounting: Ground stake mounted
Listing: UL Wet
Location: Flagpole

Luminaire Performance Criteria

Lumen Output: 972 lm Static White LED
CCT: 3000K
CRI: 90+
Life: 50,000 hr L70

Electrical Requirements

Load: 12W
Voltage: Primary: 120/277V Universal Secondary:
Driver: Integral
Control: 0-10v Dimming

Basis Of Design

Manufacturer: Amerlux
Model: Rook X Accent
Model Number: RKX-AR-F-MFL-309-TBK-HEX-GSP17

Alternates

Alternate 1: Erco Beamer
Alternate 2: Bega

Notes:

Provide all accessories for complete installation.

Image:



Detail:

E09A

Recessed Linear

Description

Recessed Linear Batwing wet listed

Physical Requirements

Dimensions: 2.5/8"W x 2.13/16"H

Construction: Extruded aluminum

Optic: Batwing

Finish: Custom Powder coated BLACK

Mounting: Ceiling, Recessed

Listing: UL Wet

Location: Vestibule and Entry Canopy Outdoor

Luminaire Performance Criteria

Lumen Output: 280 lm/ft Static White LED

CCT: 3000K

CRI: 90+

Life: 50,000 hr L70

Electrical Requirements

Load: 3.5 W/ft

Voltage: Primary: 120/277V Universal Secondary:

Driver: Integral

Control: 0-10v Dimming

Basis Of Design

Manufacturer: Axis Lighting

Model: Extend 2

Model Number: EX2R-300-90-30-BW-SL-C-UNV-DP-_-DF-_-_-+EF

Alternates

Alternate 1: A-Light LINO RECESSED

Alternate 2: Coronet

Notes:

Coordinate with ceiling type for mounting and provide all accessories for complete installation. Provide with End Feed +EF. Submit shop drawing for all linear runs.

Image:



Detail:

E09B

Recessed Linear

Description

Recessed Linear Wallwash wet listed

Physical Requirements

Dimensions: 2.5/8"W x 2.13/16"H

Construction: Extruded aluminum

Optic: Wallwash

Finish: Custom Powder coated BLACK

Mounting: Ceiling, Recessed

Listing: UL Wet

Location: Entry Canopy Outdoor

Luminaire Performance Criteria

Lumen Output: 280 lm/ft Static White LED

CCT: 3000K

CRI: 90+

Life: 50,000 hr L70

Electrical Requirements

Load: 3.5 W/ft

Voltage: Primary: 120/277V Universal Secondary:

Driver: Integral

Control: 0-10v Dimming

Basis Of Design

Manufacturer: Axis Lighting

Model: Extend 2

Model Number: EX2R-300-90-30-WW-SL-C-UNV-DP-_-DF-_-_-+EF

Alternates

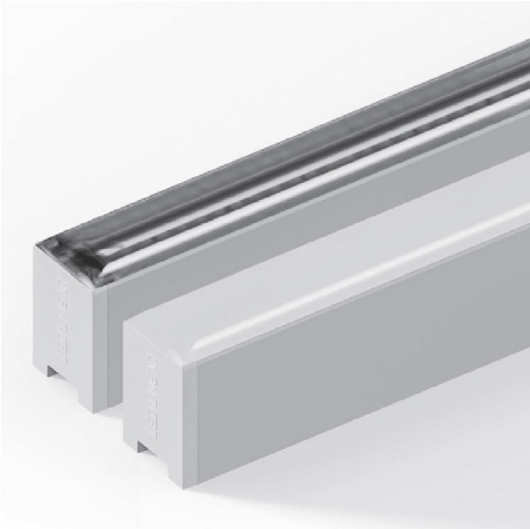
Alternate 1: A-Light LINO RECESSED

Alternate 2: Coronet

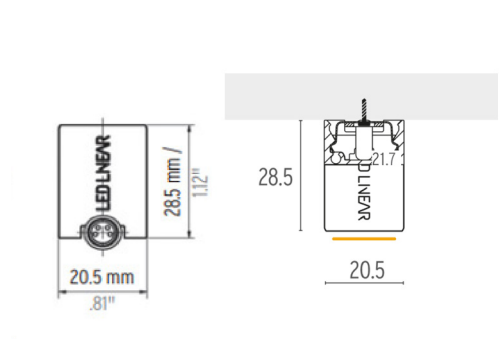
Notes:

Coordinate with ceiling type for mounting and provide all accessories for complete installation. Provide with End Feed +EF. Submit shop drawing for all linear runs.

Image:



Detail:



E10
Linear Surface Mounted

Description

Surface mounted linear for outdoor signage

Physical Requirements

Dimensions: 0.81"W x 1.12"H x length per plans
Construction: Extruded aluminum
Optic: 30 degrees
Finish: Gray
Mounting: Ceiling, Surface
Listing: UL Wet
Location: Outdoor Signage

Luminaire Performance Criteria

Lumen Output: 358 lm/ft Static White LED
CCT: 3000K
CRI: 90+
Life: 50,000 hr L70

Electrical Requirements

Load: 3.1 W/ft
Voltage: Primary: 120/277V Universal Secondary:
Driver: Remote
Control: 0-10v Dimming

Basis Of Design

Manufacturer: Led Linear
Model: Adonis
Model Number: ADONIS HE 10 W830 G 30E DC S SH IP67

Alternates

Alternate 1: LEDscape Lighting Grazer SG
Alternate 2: QTL

Notes:

Coordinate with ceiling type for mounting and provide all accessories for complete installation. Provide Side Feed. Submit shop drawing for all linear runs.

SECTION 26 09 13

ELECTRICAL POWER MONITORING SYSTEM

(Part of Work Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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 the following for monitoring and control of electrical power system:
 - 1. PC-based server hardware and software.
 - 2. Application software for monitoring and trending of electrical parameters.
 - 3. Communication network components and interface modules for Modbus TCP/IP and, where required, RS-485 Modbus RTU data transmission protocols.
- B. Related Requirements:
 - 1. Section 262413 "Switchboards".
 - 2. Section 262416 "Panelboards".
 - 3. Section 271500 "Communications Horizontal Cabling".

1.3 DEFINITIONS

- A. Ethernet: Local area network based on IEEE 802.3 standards.
- B. 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.
- C. HTML: Hypertext markup language.
- D. I/O: Input/output.
- E. KY Pulse: A term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay changing status in response to the rotation of the disk in the meter.

- F. LAN: Local area network; sometimes plural as "LANs."
- G. LCD: Liquid crystal display.
- H. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or remote-control, signaling and power-limited circuits.
- I. Modbus TCP/IP: An open protocol for exchange of process data.
- J. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
- K. PC: Personal computer; sometimes plural as "PCs."
- L. 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.
- M. RS-232: A TIA standard for asynchronous serial data communications between terminal devices.
- N. RS-485: A TIA standard for multipoint communications using two twisted-pairs.
- O. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.
- P. THD: Total harmonic distortion.
- Q. UPS: Uninterruptible power supply; used both in singular and plural context.
- R. WAN: Wide area network.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
 - 1. Attach copies of approved Product Data submittals for products (such as switchboards and switchgear) that describe power monitoring and control features to illustrate coordination among related equipment and power monitoring and control.
- B. Shop Drawings: For power monitoring and control equipment. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Outline Drawings: Indicate arrangement of components and clearance and access requirements.
 - 2. 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 to be used. Describe characteristics of network and other data communication lines.
3. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 4. Wiring Diagrams: For power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
 5. UPS sizing calculations for workstation.
 6. Surge Suppressors: Data for each device used and where applied.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Field quality-control reports.
- C. Other Informational Submittals:
 1. Manufacturer's system installation and setup guides, with data forms to plan and record options and setup decisions.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For power monitoring and control units, to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 1. Operating and applications software documentation.
 2. Software licenses.
 3. Software service agreement.
 4. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Software shall include system restore, emergency boot diskettes, and drivers for all installed hardware. Provide separately for each PC.
 5. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.
- B. Software and Firmware Operational Documentation:
 1. Self-study guide describing the process for setting equipment's network address; setting Owner's options; procedures to ensure data access from any PC on the network, using a standard Web browser; and recommended firewall setup.
 2. Software operating and upgrade manuals.
 3. Software Backup: On a magnetic media or compact disc, complete with Owner-selected options.

4. Device address list and the set point of each device and operator option, as set in applications software.
 5. Graphic file and printout of graphic screens and related icons, with legend.
- C. Software Upgrade Kit: For Owner to use in modifying software to suit future power system revisions or power monitoring and control revisions.
- D. Software licenses and upgrades required by and installed for operating and programming digital and analog devices.

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. Addressable Relays: One for every 10 installed. Furnish at least one of each type.
 2. Data Line Surge Suppressors: One for every 10 of each type installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
- B. Manufacturer Qualifications: A firm experienced in manufacturing power monitoring and control equipment similar to that indicated for this Project and with a record of successful in-service performance.
- 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 COORDINATION

- A. Coordinate features of distribution equipment and power monitoring and control components to form an integrated interconnection of compatible components.
1. Match components and interconnections for optimum performance of specified functions.
- B. Coordinate Work of this Section with those in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.

1.10 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning with Substantial Completion, provide software support for two years.
- B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include the operating systems. Upgrade shall include new or revised licenses for use of software.
 - 1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide comparable product by one of the following:
 - 1. Eaton Corporation; Cutler-Hammer products.
 - 2. Rockwell Automation, Inc.; Allen-Bradley brand.
 - 3. Schneider Electric - Power Management Operation.

2.2 FUNCTIONAL DESCRIPTION

- A. Instrumentation and Recording Devices:
 - 1. Monitor and record load profiles and chart energy consumption patterns.
 - 2. Calculate and Record:
 - a. kW, kVAR, kVA, kWh, kVARh, kVAh.
 - b. Demand kW and peak demand, with user-selectable demand interval.
 - c. Power factor and voltage / current unbalance.
- B. Power Quality Monitoring:
 - 1. Identify power system anomalies and measure, display, and record trends and alarms of the following power quality parameters:
 - a. Over / undervoltage.
 - b. Voltage unbalance.
 - c. Overcurrent.
 - d. Frequency deviation.
 - e. Total harmonic distortion (THD) for voltage and current, when supported by device.
- C. System Functions:
 - 1. Display real-time metered values from all communicating meters and breaker trip units.

2. Log alarms and events with time stamps.
3. Provide historical trending of selected parameters (e.g. kW, kWh, voltage, current) for a minimum of 12 months, based on storage sizing.
4. Generate use-configurable reports and export data to CSV or similar formats for analysis.
5. Provide one-line and equipment graphics for main and emergency switchboards and major downstream panels.

2.3 SYSTEM REQUIREMENTS

- A. Monitoring System:
 1. Provide one EPMS head-end server located in the telecommunications room, with application software installed.
 2. Provide web-based client access so that authorized users can view EPMS data from standard Owner PCs on the building LAN using a standard web browser.
 3. Provide communication interfaces to all metering devices, breaker trip units, and gateways as indicated on the drawings.
- B. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.
 1. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
 2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements as recommended by manufacturer for type of line being protected.
- C. Addressable Devices: All transmitters and receivers shall communicate unique device identification and status reports to monitoring and control clients.

2.4 OPERATING SYSTEM

- A. Software: Configured for a server and multiple client PCs, each with capability for accessing multiple devices simultaneously. Software shall include interactive graphics client and shall be Web enabled. Workstations and portable computers shall not require any software except for an Internet browser to provide connectivity and full functionality. Include a firewall recommended by manufacturer. 100 Base-T Ethernet, Modbus TCP/IP RS-232, and RS-485 digital communications.
- B. Operating System Software: Based on 64-bit, Microsoft Windows workstation operating system. Software shall have the following features:
 1. Multiuser and multitasking to allow independent activities and monitoring to occur simultaneously at different workstations.
 2. Graphical user interface to show pull-down menus and a menu tree format.

3. Capability for future additions within the indicated system size limits.

2.5 APPLICATIONS SOFTWARE

A. Basic Requirements:

1. Fully compatible with and based on the approved operating system.
2. Password-protected operator login and access; three levels, minimum.
3. Password-protected setup functions.
4. Context-sensitive online help.
5. Capability of creating, deleting, and copying files; and automatically maintaining a directory of all files, including size and location of each sequential and random-ordered record.
6. Capability for importing custom icons into graphic views to represent alarms and I/O devices.
7. Automatic and encrypted backups for database and history; automatically stored at selected workstation and encrypted with a nine-character alphanumeric password, which must be used to restore or read data contained in backup.
8. Operator audit trail for recording and reporting all changes made to user-defined system options.

B. Workstation Server Functions:

1. Support other client PCs on the LAN.
2. Maintain recorded data in databases accessible from other PCs on the LAN.

C. Data Formats:

1. User-programmable export and import of data to and from commonly used Microsoft Windows spreadsheet, database, billing, and other applications; using dynamic data exchange technology.
2. Option to convert reports and graphics to HTML format.
3. Interactive graphics.
4. Option to send preprogrammed or operator designed e-mail reports.

D. Metered Data: Display metered values in real time.

E. Equipment Documentation: Database for recording of equipment ratings and characteristics; with capability for graphic display on monitors.

F. Graphics: Interactive color-graphics platform with pull-down menus and mouse-driven generation of power system graphics, in formats widely used for such drafting; to include the following:

1. Site plan.
2. Floor plans.
3. Equipment elevations.
4. Single-line diagrams.

- G. User-Defined Monitoring and Control Events: Display and record with date and time stamps accurate to 0.1 second, and including the following:
 - 1. Operator log on/off.
 - 2. Attempted operator log on/off.
 - 3. All alarms.
 - 4. Equipment operation counters.
 - 5. Out-of-limit, pickup, trip, and no-response events.
- H. Trending Reports: Display data acquired in real-time from different meters or devices, in historical format over user-defined time; unlimited as to interval, duration, or quantity of trends.
 - 1. Spreadsheet functions of sum, delta, percent, average, mean, standard deviation, and related functions applied to recorded data.
 - 2. Charting, statistical, and display functions of standard Windows-based spreadsheet.
- I. Alarms: Display and record alarm messages from discrete input and controls outputs, according to user programmable protocol.
 - 1. Functions requiring user acknowledgment shall run in background during computer use for other applications and override other presentations when they occur.
- J. Waveform Data: Display and record waveforms on demand or automatically on an alarm or programmed event. Include the graphic displays of the following, based on user-specified criteria:
 - 1. Phase voltages, phase currents, and residual current.
 - 2. Overlay of three-phase currents, and overlay each phase voltage and current.
 - 3. Waveforms ranging in length from 2 cycles to 5 minutes.
 - 4. Disturbance and steady-state waveforms up to 512 points per cycle.
 - 5. Transient waveforms up to 83,333 points per cycle on 60-Hz base.
 - 6. Calculated waveform, based on recorded data, on a minimum of four cycles of data of the following:
 - a. THD.
 - b. rms magnitudes.
 - c. Peak values.
 - d. Crest factors.
 - e. Magnitude of individual harmonics.
- K. Data Sharing: Allow export of recorded displays and tabular data to third-party applications software.
 - 1. Tabular data shall be in the comma-separated values.
- L. Reporting: User commands initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.

1. Print a record of user-defined alarm, supervisory, and trouble events on workstation printer.
2. Sort and report by device name and by function.
3. Report type of signal (alarm, supervisory, or trouble), description, date, and time of occurrence.
4. Differentiate alarm signals from other indications.
5. When system is reset, report reset event with same information concerning device, location, date, and time.

M. Display Monitor:

1. Backlighted LCD to display metered data with touch-screen selecting device.
2. Touch-screen display shall be a minimum 12-inch diagonal, resolution of 800 by 600 RGB pixels, 256 colors; NEMA 250, Type 1 display enclosure.
3. Display four values on one screen at same time.

2.6 COMMUNICATION COMPONENTS AND NETWORKS

- A. Network Configuration: High-speed, multi-access, open nonproprietary, industry standard communication protocol; LANs complying with EIA 485, 100 Base-T Ethernet, and Modbus TCP/IP.

2.7 POWER MONITORS

- A. Separately mounted, permanently installed instrument for power monitoring and control, complying with UL 1244.
1. Enclosure: NEMA 250, Type 1.
- B. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
1. Indoor installation in nontemperature-controlled spaces that have environmental controls to maintain ambient conditions of 0 to 122 deg F (minus 18 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
- C. Advanced Power Quality Meter – Building Entrance Typical
1. The metering device used to monitor the low voltage switchboard at the building main or on the low voltage side of building main transformers shall have at minimum the following features:
 - a. Voltage and current inputs—three (3) phase inputs; direct connect to 600 VAC; five (5) amperes (A) nominal current inputs.
 - b. High accuracy standards—meets stringent IEC and ANSI measurement accuracy standards such as IEC 62053-22 Class 0.1S, ANSI C12.20 0.2 Class 0.1.
 - c. Fault recording and waveform capture:

- 1) Simultaneously capture voltage and current channels for sub-cycle disturbance, transients, as well as multi-cycle sags, swells and outages in quick succession.
- 2) 1024 samples per cycle waveform recording, 17 μ s transient capture (60 Hz).
- 3) Configurable to provide COMTRADE waveforms for all captures.
- d. Disturbance detection and disturbance direction indication:
 - 1) High-speed sag/swell detection of voltage disturbances on a cycle-by-cycle basis, providing duration of the disturbance
 - 2) Detect disturbances less than one cycle in duration.
 - 3) Determine the location of a disturbance more quickly and accurately by determining the direction of the disturbance relative to the meter. Capture analysis results in the event log, along with a timestamp and confidence level indicating level of certainty.
- e. Supported measured and calculated metering parameters—four-quadrant metering,
 - 1) Energy totals
 - a) Real, reactive and apparent energy
 - b) Real energy – into the load and out of the load
 - 2) Instantaneous RMS values – (Total and per Phase)
 - a) Real, reactive and apparent power
 - b) Current (average and per phase)
 - c) Current (Neutral)
 - d) Voltage (L-L and L-N) (average and per phase)
 - e) Power factor (displacement and total)
 - f) Frequency
 - 3) Demand / Record on-board values
 - a) Real, reactive and apparent power (maximum)
 - b) Current (maximum)
 - c) Voltage (minimum and maximum)
 - d) Power Factor (minimum and maximum)
 - e) Frequency (minimum and maximum)
 - 4) Power Quality
 - a) Harmonic Distortion (voltage and current)
 - b) Individual Harmonics to 63rd harmonics
 - c) Waveform capture
 - d) Sag and Swell detection with disturbance direction detection
- f. High-visibility display with the following characteristics:
 - 1) User programmable to display up to four (4) quantities per screen.
 - 2) Capable of displaying graphical metering data such as phasor diagrams.
- g. I/O – As required and noted on the drawings for a digital status input monitoring of other devices such as HVL switch status, Blown Fuse Indication, SPD Alarm status
- h. Communications capability—multi-port Ethernet and serial communications with at least two Ethernet ports and two RS485 serial port. Functionality through Ethernet connectivity includes e-mail on alarm, on-board web server, SNMP network management, NTP time synchronization, Ethernet-to-serial RS-485 gateway, Modbus RTU protocol.
- i. On-board logging:

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- 1) Non-volatile time stamps with on-board logging of I/O conditions, alarms, and all measured parameters; waveform captures along with energy and demand.
 - 2) Continuous recording of intervals down to one-half ($\frac{1}{2}$) cycle.
 - j. On-board web server can be used for:
 - 1) Access to real-time values and basic power quality information using web browser.
 - 2) Basic meter configuration.
 - k. Alarming capabilities:
 - 1) Set-point driven alarming capability.
 - 2) Generate an email notification upon an alarm condition.
 - 3) Millisecond resolution timestamp on alarm entries.
 - l. Time-stamped event log (1 millisecond resolution) with the following characteristics:
 - 1) Support at least 500 events, programmable up to a maximum of 20000 events.
 - 2) For each event, record date and time, cause and effect, and priority.
 - 3) Record all events relating to set-point activity, relay operation and self-diagnostics.
 - 4) Minimum event recording response time is one-half ($\frac{1}{2}$) cycle (8.3ms 60Hz) for high-speed events and one (1) second for other events.
 - 5) Programmable set-point events.
 - m. Power quality analysis and compliance monitoring:
 - 1) Without separate software, have the following capabilities:
 - a) Display statistical indicators of power quality on the front display.
 - b) Compare power quality parameters with an absolute or relative set point, and alert (via e-mail or pager).
 - c) Support EN50160 reporting for compliance monitoring.
 - 2) Low pass anti-aliasing signal.
 - n. Schneider Electric ION9000 series, Eaton PXM3000 or approved equal by the switchboard manufacturer.
- D. Breaker Metering Trip Unit
 - 1. The metering device used on main and feeder breakers in switchboards, distribution panelboards and main breakers on panelboards; provide basic metering of the load and also breaker condition information and activity (loads from 6,000A to 15 A as designated on the drawings):
 - a. Voltage reference – provided by the switchboard or distribution panel source in trip unit.
 - b. Current sensing – provided through the breaker protection current transformers.
 - c. Supported monitoring parameters—full range of 3-phase voltage, current, power, and energy measurements.
 - 1) Energy totals
 - a) Real, reactive and apparent energy
 - b) Real energy – into the load and out of the load
 - 2) Instantaneous RMS values – (Total and per Phase)
 - a) Real, reactive and apparent power

- b) Current (average and per phase)
- c) Current (Neutral and Ground)
- d) Current % of Load
- e) Current unbalanced
- f) Voltage (L-L and L-N) (average and per phase)
- g) Voltage unbalance
- h) Power factor (displacement)
- i) Frequency
- 3) Demand readings with Date and Time
 - a) Real, reactive and apparent power (maximum)
 - b) Current (maximum)
- 4) Minimum and Maximum readings
 - a) Voltage (minimum and maximum)
 - b) Crest Factor
 - c) Power Factor (minimum and maximum)
 - d) Frequency (minimum and maximum)
- 5) Breaker Information
 - a) Status – Open / Closed / Tripped
 - b) Last Trip – Date and Time
 - c) Ground Fault Alarm Status
 - d) Trip settings of breaker
- d. Communications – metering trip units are internally wired serial RS-485 Modbus, Ethernet Modbus TCP through a gateway provide two Ethernet ports. Through a standard web browser; and monitor breaker load, status and settings in default pages from the factory.
- e. Schneider Electric Micrologic Type P trip unit and Type E trip unit, Eaton PXR 25 or approved equal, by the switchboard manufacturer.

E. Metering Enclosures

1. Any metering enclosed cabinets supplied shall meet the following specifications:
 - a. Minimum UL type 1 listed steel enclosure with factory-supplied knockouts.
 - b. Lockable and provide for the application of a security seal.
 - c. Available options for NEMA Type 1 and Type 4X applications.
 - d. Single set of incoming terminals for connecting the voltage metering leads.
 - e. Control power and voltage sensing power separated for distribution to each meter from main set of incoming terminals.
 - f. External control power transformers not required for any power systems up to, and including, 480 volts.
 - g. Standard wiring harnesses for control power and voltage sensing to connect each meter internally.
 - h. Common daisy chain wiring for communications wiring, with a single loop for all meters connected to the circuit and each end terminated in a common location. Communication wiring installed such that interference from the power wiring is minimized.
 - i. Shorting terminal blocks for connecting the current transformer leads from the field to all ordered meters.
 - j. Terminal blocks for incoming and outgoing communications circuit connections.

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F. Onboard Data Logging:

1. Store logged data, alarms, events, and waveforms in 800 KB of onboard nonvolatile memory.
2. Stored Data:
 - a. Billing Log: User configurable; data shall be recorded every 15 minutes, identified by month, day, and 15-minute interval. Accumulate 24 months of monthly data, 32 days of daily data, and between 2 and 52 days of 15-minute interval data, depending on number of quantities selected.
 - b. Custom Data Logs: Three user-defined log(s) holding up to 96 parameters. Date and time stamp each entry to the second and include the following user definitions:
 - 1) Schedule interval.
 - 2) Event definition.
 - 3) Configured as "fill-and-hold" or "circular, first-in first-out."
 - c. Alarm Log: Include time, date, event information, and coincident information for each defined alarm or event.
 - d. Waveform Log: Store captured waveforms configured as "fill-and-hold" or "circular, first-in first-out."
3. Default values for all logs shall be initially set at factory, with logging to begin on device power up.

G. Alarms.

1. User Options:
 - a. Define pickup, dropout, and delay.
 - b. Assign one of four severity levels to make it easier for user to respond to the most important events first.
 - c. Allow for combining up to four alarms using Boolean-type logic statements for outputting a single alarm.
2. Alarm Events:
 - a. Over/undercurrent.
 - b. Over/undervoltage.
 - c. Current imbalance.
 - d. Phase loss, current.
 - e. Phase loss, voltage.
 - f. Voltage imbalance.
 - g. Over kW demand.
 - h. Phase reversal.
 - i. Digital input off/on.
 - j. End of incremental energy interval.
 - k. End of demand interval.

- H. Control Power: 90- to 457-V ac or 100- to 300-V dc.

2.8 WORKSTATION HARDWARE

- A. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
 - 1. Indoor installation in spaces that have environmental controls to maintain ambient conditions of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
- B. Server: 19-inch rack-mount server (1U or 2U) or virtual machine as approved by Owner IT, designed for the latest version of Windows operating system.
 - 1. Server style will be stand alone with power monitoring application and database residing on the same machine.
 - 2. 64 GB RAM or more
 - 3. Hard Disk - 2 – 1 TB HD in RAID 1 configuration for back-up
 - 4. Microsoft Operating System shall be the latest.
 - 5. Microsoft SQL Server shall be the latest appropriate licensed for server size.
 - 6. Microsoft Excel and PDF viewer for local report export viewing
 - 7. Any device licenses shall be 25% more than immediately required for future expansion.
 - 8. Monitor – 21-inch LED or larger for easy viewing
 - 9. Web clients – 5 or more for remote user viewing
 - 10. Printer – color laser for print out of reports and disturbance waveforms.
 - 11. Power to be supplied from UPS circuit for system stability

2.9 LAN CABLES

- A. Comply with Section 271500 "Communications Horizontal Cabling."
- B. RS-485 Cable:
 - 1. PVC-Jacketed, RS-485 Cable: Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, PVC insulation, unshielded, PVC jacket, and NFPA 70, Type CMG.
 - 2. Plenum-Type, RS-485 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and fluorinated-ethylene-propylene jacket, and NFPA 70, Type CMP.
- C. Unshielded Twisted Pair Cables: Category 6 as specified for horizontal cable for data service in Section 27 15 00 "Communications Horizontal Cabling."

2.10 LOW-VOLTAGE WIRING

- A. Comply with Section 260523 "Control-Voltage Electrical Power Cables."

- B. Low-Voltage Control Cable: Multiple conductor, color-coded, No. 20 AWG copper, minimum.
 - 1. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
 - 2. Ordinary Switching Circuits: Three conductors unless otherwise indicated.
 - 3. Switching Circuits with Pilot Lights or Locator Feature: Five conductors unless otherwise indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION AND COMMISSIONING

- A. Installation.
 - 1. System components, including meters, electronic trip units, sensors, motor protection devices, relays, etc. included within power equipment lineups, shall be factory installed, wired, and tested prior to shipment to the job site.
 - 2. All control power, CT, PT, and data communications wiring shall be factory wired and harnessed within the equipment enclosure.
 - 3. All external wiring required to connect equipment lineups shall be installed by the electrical contractor.
 - 4. Contractor interconnection wiring requirements shall be identified on system drawings.
 - 5. Vendor field technicians shall verify accuracy of installation prior to commissioning.
- B. System Commissioning and Acceptance.
 - 1. Factory-trained personnel shall perform on-site commissioning using automated commissioning tools to improve consistency and quality of commissioning.
 - 2. Engineering drawings shall be made available to the client for all EPMS projects.
 - 3. On-site commissioning and initial user training of the EPMS shall be included in bid.
 - 4. Commissioning shall include detailed scope of work checklist document with delivered functionality listed and checked. Shall include a screen capture and backup of all graphic.
 - 5. Commissioning shall include a full working demonstration of the system under normal operating conditions and simulated scenarios.

3.3 CABLING

- A. Comply with NECA 1.
- B. Install cables and wiring according to requirements in Section 271500 "Communications Horizontal Cabling."
- C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.
- D. Wiring Method: Install wiring in raceway and cable tray 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. Use NRTL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces. Install LAN cables using techniques, practices, and methods that are consistent with specified category rating of components and that ensure specified category performance of completed and linked signal paths, end to end.
- E. Install cables without damaging conductors, shield, or jacket.

3.4 IDENTIFICATION

- A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."
- B. Label each power monitoring and control module with a unique designation.

3.5 GROUNDING

- A. Comply with IEEE 1100, "Recommended Practice for Powering and Grounding Electronic Equipment."

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 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. Electrical Tests: Use caution when testing devices containing solid-state components.
 2. Continuity tests of circuits.
 3. Operational Tests: Set and operate controls at workstation and at monitored and controlled devices to demonstrate their functions and capabilities. Use a methodical sequence that cues and reproduces actual operating functions as recommended by manufacturer. Submit sequences for approval. Note response to each test command and operation. Note time intervals between initiation of alarm conditions and registration of alarms at central-processing workstation.
 - a. Coordinate testing required by this Section with that required by Sections specifying equipment being monitored and controlled. Test LANs according to requirements in Section 271500 "Communications Horizontal Cabling."
 - b. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of calculated battery operating time.
 - c. Verify accuracy of graphic screens and icons.
 - d. Metering Test: Load feeders, measure loads on feeder conductor with an rms reading clamp-on ammeter, and simultaneously read indicated current on the same phase at central-processing workstation. Record and compare values measured at the two locations. Resolve discrepancies greater than 5 percent and record resolution method and results.
 - e. Record metered values, control settings, operations, cues, time intervals, and functional observations and submit test reports printed by workstation printer.
- E. Power monitoring and control equipment will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.
- G. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.
- H. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.
- I. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.
- J. Remove and replace malfunctioning devices and circuits and retest as specified above.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain systems. See Section 017900 "Demonstration and Training."
 - 1. Train Owner's management and maintenance personnel in interpreting and using monitoring displays and in configuring and using software and reports. Include troubleshooting, servicing, adjusting, and maintaining equipment. Provide a minimum of 6 hours' training.
 - 2. Training Aid: Use approved final versions of software and maintenance manuals as training aids.

3.8 ON-SITE ASSISTANCE

- 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. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

END OF SECTION

SECTION 26 09 43

NETWORK LIGHTING CONTROLS

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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 includes all hardware, software, and communication requirements for the centralized lighting control systems.
 - 1. Contractor shall coordinate all of the work in this section with all of the trades covered in other sections of the specification to provide a complete and operable lighting control system.
 - 2. Provide a complete system for the control of lighting and other equipment as indicated on the Drawings, to perform as required in the Sequence of Operations schedule, and as further defined herein.
 - 3. Products and systems provided shall provide all functionality as described in Division 26 Section "Sequence of Operations for Lighting Control." Provide all parts required to provide functionality, even if not specifically mentioned in this Section.
 - 4. Requirements are indicated elsewhere in these specifications for work including, but not limited to, raceways and electrical boxes and fittings required for installation of control equipment and wiring.
 - 5. Requirements are indicated elsewhere in these specifications for work including, but not limited to, wiring devices and sensors not connected to any other lighting control system.
- B. Related Sections include the following:
 - 1. Section 26 27 26 "Wiring Devices" for line voltage switches and dimmers without occupancy sensors or timers.
 - 2. Section 26 05 23 "Control-Voltage Electrical Power Cables".
 - 3. Section 26 09 23 "Lighting Control Devices" for basic occupancy, and vacancy lighting control devices and room controllers and accessories.
 - 4. Section 27 10 00 "Structured Cabling Systems".
 - 5. Section 01 91 14 "MEP Commissioning Plan".

1.3 DEFINITIONS

- A. BACnet: A networking communication protocol that complies with ASHRAE 135.
- B. BAS: Building automation system.
- C. DALI: Digital addressable lighting interface.
- D. DMX: Digital Multiplex digital communication control protocol.
- E. Fade Override: The ability to temporarily set fade times to zero for all lighting scenes.
- F. Fade Rate: The time it takes each zone to arrive at the next scene, dependent on the degree of change in lighting level.
- G. Fade Time: The time it takes all zones to fade from one lighting scene to another, with all zones arriving at the next scene at the same time.
- H. LED: Light-emitting diode.
- I. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
- J. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling and power-limited circuits.
- K. Major Motion: Detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s, such as walking movements.
- L. Minor Motion: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., such as hand movements.
- M. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
- ~~N. PC: Personal computer; sometimes plural as "PCs."~~
- O. PIR: Passive infrared.
- P. RS-485: A serial network protocol, similar to RS-232, complying with TIA/EIA-485-A.
- Q. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.
- R. SCR: Silicon-controlled rectifier.

- S. Zone: A fixture or group of fixtures controlled simultaneously as a single entity. Also known as a "channel."

1.4 SUBSTITUTIONS

- A. Performance Requirements: If hardware, software, devices, or other system components are provided, other than a product or manufacturer named in the drawings or specifications, the Contractor assumes responsibility to coordinate additional quantities, interfaces, devices, etc. and their locations as necessary to fulfill all functionality noted throughout the drawings and specifications.
- B. Comparison Report: In addition to the requirements of substitution requests, as described in Division 1, the Contractor shall submit a report including the following information. Submittals including substitutions without a prior Comparison Report may be rejected without review, with Contractor responsibility for any construction schedule impact.
 - 1. Itemized cost comparison: including unit costs of materials and labor for all components of a complete system, comparing a system with all specified components, as well as a system with any proposed substituted components.
 - 2. Deviations from design: a list of any required deviations from the design documentation such as alternative equipment locations, ratings, sizes, clearances, wire types, wiring connector types, server hardware requirements, etc.

1.5 SUBMITTALS

- A. Submit the items listed below in accordance with the provisions of Section 01 33 00 "Submittal Procedures."
- B. Product Data: For all components including but not limited to programmable central controllers, transceivers, panels, relays, dimmers, switches, occupancy sensors, ballasts and interfaces, and other ancillary equipment.
 - 1. Dimensions, features, characteristics, ratings, and labels.
 - 2. All options for device and cover plate style, color, and material.
 - 3. Compatibility with load types, lamps, ballasts, control protocols, etc.
- C. Shop Drawings:
 - 1. Outline Drawings: Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
 - 2. Single Line Block Diagram: Show quantity of devices specific to the project. Typical riser diagrams are not acceptable; however repetitive portions of diagram can be annotated with quantity. Show interconnections between components specified in this Section. Identify any line-voltage power connections required by the system. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other

devices to be used. Describe characteristics of network and other data communication lines.

3. Wiring Diagrams: Show field-installed power, signal, and control wiring. Coordinate nomenclature and presentation with the single line block diagram.
4. System Floor Plans: To scale, showing the location of each device and equipment and identification of line-voltage power connections required by the system, and control wiring connections. Indicate circuit and panelboard to be used as well as the lighting controller equipment load on the circuit for all line-voltage power connections.
5. Sensor Coverage Floor Plans: To scale, drawings from occupancy sensor manufacturer indicating full occupancy sensor coverage is achieved within each room where sensors are indicated.

D. Sequence of Operations:

1. Provide comprehensive sequence of operations with a description of operation for each room, including hierarchy of operations.
 - a. Sequence of operations shall confirm that submitted system can achieve all functionality required by Section 26 09 93 "Lighting Control Sequence of Operations."
 - b. Each unique sequence of operations shall be described in narrative format, with applicable room numbers or control zones noted.
 - c. Lighting control equipment submittal will not be reviewed without this information.
 - d. Non-narrative formats will not be accepted.

E. Coordination:

1. List all monitoring and control devices and systems, as specified in other Sections, that lighting controls must communicate or otherwise be compatible with.
2. Indicate interconnecting signal and control wiring and interfacing devices that prove compatibility of these inputs and outputs.
3. For networked controls, list network protocols and provide statements from manufacturers that input and output devices meet interoperability requirements of the network protocol.

1.6 CLOSEOUT SUBMITTALS

- A. Submit the items listed below in accordance with the provisions of Section 01 77 00 "Closeout Procedures."
- B. Software and Firmware Operational Documentation:
 1. Software operating and upgrade manuals.
 2. Program Software Backup: On a magnetic media or compact disc readable by the owner's computer systems, complete with data files.
 3. Printout of software application and graphic screens.
- C. Field quality-control test reports.

- D. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.
- E. Operation and Maintenance Data:
 - 1. Software manuals.
 - 2. Adjustments of scene preset controls, adjustable fade rates, and fade overrides.
 - 3. Operation of adjustable zone controls.
 - 4. Testing and adjusting of panic and emergency power features.
 - 5. Spare parts data listing
 - 6. Source and current prices of replacement parts and supplies.
 - 7. Recommended maintenance procedures and intervals.
- F. Record Documents: Indicate on floor plans and schedules the final installed conditions of the following system details.
 - 1. Assign unique device identifiers for all switches, sensors, relays, enclosures, and other discrete components of the system. Use identifiers consistently throughout the documentation of the record set.
 - 2. Floor plans:
 - a. Installed device (switch and sensor) locations, including unique device identifiers.
 - b. Lighting fixture layout, indicating fixture types, with relay identifier noted for each fixture controlled by that relay.
 - c. Lighting fixture layout shall indicate the branch circuit panelboard and circuit number for each light fixture.
 - d. Fixtures not controlled by the lighting control system shall not be shown on the floor plans.
 - 3. Schedules: Indicate the following for each control zone.
 - a. The unique identifier for that zone
 - b. Room(s) containing light fixtures controlled in the zone
 - c. Device inputs associated with that zone. The relationships depicted shall reflect the final installed and programmed conditions.
 - d. Control channel identification reflecting the final installed and programmed conditions used in system communications.
 - e. Programming of that zone, including normal on/off times, override operation, operation in power outage, etc.
- G. Warranty: Special warranty specified in this Section.

1.7 QUALITY ASSURANCE

- A. Source Limitations: Obtain all lighting control components through one source from a single manufacturer, or from manufacturers approved by the warranting manufacturer if not available from the warranting manufacturer.
- B. Manufacturers shall have a minimum of 5 years experience in manufacturing, installing, and servicing similar systems or components.

- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with 47 Code of Federal Regulations, Subparts A and B, for Class A digital devices.
- E. Comply with NFPA 70.

1.8 COORDINATION

- A. Coordinate lighting control components to form an integrated interconnection of compatible components.
 - 1. Match components and interconnections for optimum performance of lighting control functions.
 - 2. Coordinate lighting controls with and include all custom programming, graphics, wiring, and interfaces required for the following systems where indicated in sequence of operations:
 - a. Curtains and drapes
 - b. Blackout curtains
 - c. Projector screens
 - d. Manually positioned partitions
- B. Coordinate lighting control components specified in this Section with components specified in Section 26 24 16 "Panelboards."
- C. Lighting control system manufacturer to ensure that, where required, the occupancy sensors are compatible with and integrate into the lighting control system.
- D. Coordinate layout and installation of ceiling-mounted and wall-mounted devices with other construction that penetrates ceilings and walls or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship or from transient voltage surges within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Failure of software input/output to execute switching or dimming commands.
 - b. Failure of modular relays to operate under manual or software commands.
 - c. Damage from transient voltage surges.
 - 2. Warranty Period: Three years from date of Substantial Completion.

3. Extended Warranty Period Failure Due to Transient Voltage Surges: Cost of replacement parts (materials only, f.o.b. the nearest shipping point to Project site), for eight years, that failed in service due to transient voltage surges.
4. Extended Warranty Period for Electrically Held Relays: Ten years from date of Substantial Completion.

1.10 EXTRA MATERIALS

- 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. Electrically Held Relays: Equal to 10 percent of amount installed for each size indicated, but no fewer than 5 relays.

1.11 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning with Substantial Completion, provide software support for two years.
- B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
 1. Provide 30 days' notice to Owner to allow scheduling and access to system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 1. Lutron Electronics Co., Inc. (Athena System)
 2. Acuity (nLight)
 3. Legrand (Wattstopper)
- B. It is the Contractor's responsibility to confirm and provide a system comprised of the named manufacturers' components, and/or any other manufacturers' components, that achieves the functions described within the sequence of operations.

2.2 GENERAL

- A. The system installed shall be able to accommodate minimum of 35% spare capacity.

- B. Where emergency circuits are controlled, provide units including normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924. Dimming zones shall automatically illuminate to 100% upon loss of normal power or input from the fire alarm system.

2.3 LIGHTING MANAGEMENT PANELS (GATEWAYS)

- A. Lighting Management Panels (gateways) shall support web-based analytics, visualization software, lighting network configuration tools and building management integration. Gateways shall include embedded web server, WiFi adapter and visual data interface. \
- B. Gateways shall be supplied in a pre-assembled NEMA listed enclosure with terminal blocks listed for field wiring. Panels shall be installed in an accessible location and provided with power and data comms connections.
- C. Gateways shall enable Light Management software to control and monitor the lighting control system.
- D. Gateways shall utilize Ethernet connectivity to allow cloud based lighting control and system management.
 - 1. Configure portable user interfaces with html5.
 - 2. Upgrade and configure systems remotely over the TCP/IP network.
 - 3. Communicate information securely with Secure Sockets Layer (SSL) on IP network.
 - 4. View lighting installation graphically with fixtures, sensors, switches and bridges shown on building plans.
- E. Integrate bridge devices, lighting panels, load controllers, switches, dimmers, scene controllers, sensors, shades (where applicable), preset lighting controls, and external inputs into single customizable, multiple failsafe lighting control system, operable manually, automatically or through computer control.
- F. Astronomical time clock.
- G. BACnet Integration
 - 1. Provide ability to communicate by means of BACnet IP communication to lighting management system from a user-supplied 10BASE-T or 100BASE-T Ethernet network.
 - 2. Each Lighting Management Panel processor requires license for BACnet integration.
 - 3. Basic BACnet integration license for lights
 - a. The BACnet integrator can command:
 - 1) Area light output
 - 2) Area enable or disable afterhours mode
 - 3) Area load shed level
 - 4) Area load shed enable/disable
 - 4. The BACnet integrator can monitor:
 - a. Area on/off status
 - b. Area occupancy status

- c. Area fault
 - d. Area load shed status
 - e. Area instantaneous energy usage
- H. Maintain a backup of the programming in a non-volatile memory capable of lasting more than ten years without power.
- I. Provide enhanced security by:
- 1. HTTPS Server
 - 2. U.S. Government security standard of Federal Information Processing Standard (FIPS) Publication 140-2, Level 1, Inside.

2.4 LIGHTING CONTROL PANELS

- A. Lighting Control (dimming/relay) Panels shall be installed in an accessible location and form part of the lighting control system network.
- B. Dimming and Switching (relay) panels shall be delivered and installed as a UL listed factory assembled panel:
- 1. Field wiring accessible from front of panel without need to remove dimmer assemblies or other components.
 - 2. Ship panels 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.
 - 3. Panels passively cooled via free-convection, unaided by fans or other means.
 - 4. Panels contain branch circuit protection for each input circuit unless the panel is a dedicated feed-through type panel or otherwise indicated on the drawings.
 - 5. Branch circuit breakers shall meet following performance requirements:
 - a. Listed to UL 489 as molded case circuit breaker for use on lighting circuits.
 - b. Contain visual trip indicator; rated at 10,000 AIC (120 V Dimming), 14,000 AIC (277 V Dimming), and 18,000 AIC (277 V Switching).
 - c. 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.
 - d. Accept tag-out/lock-out devices to secure circuit breakers in off position when servicing loads.
 - e. Replaceable without moving or replacing dimmer/relay assemblies or other components in panel.
 - f. UL listed as switch duty (SWD) so that loads can be switched on and off by breakers.
 - g. Minimum UL listed Short Circuit Current Rating (SCCR) of 25,000A (120V panels) and 65,000A (277V panels).
- C. Lighting Control Panels:

1. Rated life of relays shall be 1,000,000 cycles as a minimum.
 2. Load shall be 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.
 4. Provide following capabilities:
 - a. Operate circuits directly from panel processor for system diagnostics and provide feedback of system operation.
 - b. Electronically assign each circuit to any zone in lighting control system.
 - c. Determine normal/emergency function of panel and set emergency lighting levels.
 5. Where indicated on Drawings, panels to provide two control links. Each circuit to be capable of transferring control based on independent programming between architectural control systems.
 6. React to changes from control within 20 milliseconds.
- D. Diagnostics and Service:
1. Replacing dimmer/relay shall not require re-programming of system or processor.
 2. Dimmers/relays shall include diagnostic LEDs to verify proper operation and assist in system troubleshooting.
 3. Dimming/relay panels shall include tiered control scheme for dealing with component failure that minimizes loss of control for occupant.
 - a. If lighting control system fails, lights shall remain at current level. Panel processor provides local control of lights until system is repaired.
 - b. If panel processor fails, lights shall 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.
 - c. If dimmer fails, factory-installed mechanical bypass jumpers shall allow each dimmer to be mechanically bypassed. Mechanical bypass device shall allow for switching operation of connected load with dimmer removed by means of circuit breaker.

2.5 LIGHTING ZONE CONTROLLER

- A. Description: Factory fabricated, network connected control system device, to switch or dim zones, and interconnect and distribute power to system devices.
1. Mounting:
 - a. Orientation: Suitable for orienting horizontally or vertically, to walls, structure, top or bottom of ceilings, with no impact on ventilation, warranty, or ratings.
 - b. Enclosure: Integral electrical enclosure installed directly to surfaces where indicated, or provide junction boxes of size and quantity as required.
 - c. Plenum: Suitable for mounting within an environmental air plenum.
 2. Operating Conditions: Passively cooled without any moving ventilation components.
 - a. Operating Temperature: 32° to 104° F (0° to 40° C)
 - b. Relative Humidity: 20 to 90% non-condensing
 3. System connectivity:

- a. Network: Incorporate digital communications via wiring and protocols as required.
- b. Analog signals: Accept or generate analog signals as required or specified for emergency interfaces, switches and sensors, or other building systems.
- c. Power: Provide power to any connected lighting control switches and sensors at required voltage and current.

2.6 LIGHTING MANAGEMENT SYSTEM SOFTWARE

- A. Provide system software and hardware that is designed, tested, manufactured, and warranted by single manufacturer.
- B. System Software:
 - 1. Single Sign-On and Multi-factor Authentication:
 - a. Product: Manufacturer setup service for single sign-on.
 - b. Domain-based identity authentication enabling IT to enforce SSO, MFA, and 2FA.
 - c. Supports SAML and OIDC.
- C. Configuration Setup Software:
 - 1. Suitable to make system programming and configuration changes.
 - 2. Windows-based, capable of running on either central server or remote client over TCP/IP connection.
 - 3. Back-Up Project Database: Allows user to back up project database that holds configuration information for system, including keypad programming, area scenes, daylighting, occupancy programming, emergency levels, night lights, and time clock.
 - 4. Publish Project Database: Allows user to send new project database to processors and devices. Project database holds configuration information for system, including keypad programming, area scenes, daylighting, occupancy programming, emergency levels, night lights, and time clock.
 - 5. Allows 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 configuration for the following in each area:
 - 1) Lighting scene.
 - 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.

D. API Integration:

- 1. Support communication, without requiring interface, between lighting control system and third-party systems via RESTful API.
- 2. 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.

E. Mobile Application:

- 1. General Requirements:
 - a. Constant internet connection to lighting control panel processors and gateways.
 - b. Support multiple platforms and devices; runs from tablet or mobile phone.
 - c. Provide functionality listed below available via single application.
- 2. System Navigation and Operation:
 - a. Support on-site and remote programming and control of multiple systems from iOS or Android mobile device.
 - b. Does not require LAN connection to operate. Operates locally or remotely with internet connection to device (e.g., laptop).
 - c. Navigate between lighting control systems for control.
- 3. Administration:
 - a. Users: Allows new user accounts to be created and existing user accounts to be edited.
 - b. Share access to lighting control system for one day, one week, or permanently.
- 4. Control of Lights:
 - a. Modify lighting zone levels and activate scenes, reflected in space in real time.
 - b. Make and save adjustments to scenes.
 - c. Rename scenes and zones.

- 1) Control intensity, correlated color temperature, saturated color, and vibrancy, reflected in space in real time.
 - 2) Save intensity, correlated color temperature, saturated color, and vibrancy to scenes reflected in space in real time.
 - d. Static-White Drivers:
 - 1) Control intensity reflected in space in real time.
 - 2) Save intensity to scenes reflected in space in real time.
 5. Load Shedding:
 - a. Allow building manager to apply load shed reduction, thereby reducing building's power usage; load shedding triggered via mobile application, BACnet or, RESTful API integration.
 6. Scheduling: Schedule time of day and astronomic time clock events to automate functions.
 - a. Group scheduled events into timeclock groups.
 - b. Enable and disable entire timeclock groups from single place.
 - c. Create one-time or recurring scheduled events by day of week, week of month, specific date range.
 - d. Exclude scheduled events by holidays or other specific date exclusions.
 - e. Enable or disable individual scheduled events.
- F. Data Insights Software:
1. One annual license required per system.
 2. General Requirements:
 - a. No on-site hosting server (neither physical nor virtual). Manufacturers requiring on-site servers requiring annual maintenance are not acceptable. System requiring third-party servers to be pre-approved by IT department before acceptance with written approval.
 - b. Web-based; runs on updated browsers including Edge, Chrome, and Safari.
 - c. Constant internet connection to all lighting control system processors and gateways.
 - d. Support multiple platforms and devices; runs from tablet, desktop, laptop.
 - e. User interface supports multi-touch gestures such as pinch to zoom, drag to pan, etc.
 - f. Utilizes HTTPS (industry-standard certificate-based encryption and authentication for security).
 - g. Provide functionality listed below via single application.
 3. System Navigation and Operation:
 - a. Performed using graphical floor plan view or a generic system layout.
 - b. Graphical Floor Plan View: Utilize customized CAD based drawing of building. Pan and zoom feature allows for easy navigation; dynamically adjusts details presented based on zoom level.
 - c. Operate locally or remotely with internet connection.
 - d. Allow user to navigate through multiple connected lighting control systems spanning multiple buildings.
 4. Software Updates:
 - a. Provide software feature updates, enhancements, and security patches automatically with no disruption to system or space.
 5. Occupancy:
 - a. Capable of monitoring historical area occupancy.

- b. Monitor energy savings due to occupancy with granularity to individual area.
- 6. Reporting: Provide reporting capability that allows building manager to gather real-time and historical information about system.
 - a. Energy Reports: Show comparison of cumulative energy used over period of time for one or more areas.
 - 1) Capable of displaying historic energy savings in kWh saved.
 - 2) Capable of displaying historical views in time periods (days, weeks, months).
 - b. Power Reports: Show power usage trend over period of time for one or more areas.
 - c. Space Utilization/Occupancy Reports: Show historical occupancy over period of time for one or more areas using graphical floor plan, generic system layout, and/or graphs and charts.
- 7. Alerting: Detect missing, damaged, and nonfunctional devices and communicate to building manager.
 - a. Types of Device Alerts:
 - 1) Device not responding.
 - 2) LED driver missing and failed.
 - 3) Lamp failure.
 - 4) Low battery alerts.
 - 5) Internet connection interruption.
 - b. Types of Notifications:
 - 1) Daily email to configurable list.
 - 2) Configurable time of email notification.
 - c. Troubleshooting Guidance:
 - 1) In-app guidance to general knowledge.
 - 2) Specific support next to individual device alert.
- 1. Training: In-app messaging, walkthroughs, and notifications of changes and new features.
- 2. Administration:
 - a. Share user access across entire system including mobile application.

2.7 LOW-VOLTAGE WALL STATIONS

- A. System Wall Stations
 - 1. Part of the Lighting Management System.
- B. Functionality:
 - 1. Upon button press, LEDs to immediately illuminate.
 - 2. LEDs to reflect the true system status. LEDs to remain illuminated if the button press was properly processed or the LEDs turn off if the button press was not processed.
 - 3. Allow for easy reprogramming without replacing unit.
 - 4. Replacement of units does not require reprogramming.
- C. Color: White or as directed by Architect
 - 1. Provide faceplates with concealed mounting hardware.
 - 2. Engrave wall stations with appropriate button, zone, and scene engraving descriptions.

3. Silk-screened borders, logos, and graduations to use graphic process that chemically bonds graphics to faceplate, resistant to removal by scratching and cleaning.
 4. Software Configuration:
 5. Customizable control station device button functionality:
 - a. Buttons can be programmed to perform single defined action.
 - b. Buttons can be programmed to perform defined action on press and defined action on release.
- D. Control station device LEDs to support logic that defines when it is illuminated:
1. Scene logic (logic is true when all zones are at defined levels).
 2. Room logic (logic is true when at least one zone is on).
 3. Pathway (logic is true when at least one zone is on).
 4. Last scene (logic is true when spaces are in defined scenes).

2.8 DIMMERS AND DIMMER MODULES

- A. Comply with UL 508.
1. Audible Noise and Radio-Frequency Interference Suppression: Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dimmer noise or radio-frequency interference. Modules shall include integral or external filters to suppress audible noise and radio-frequency interference.
 2. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.
- B. Operation: Automatically changes variable dimmer settings of indicated number of zones simultaneously from one preset scene to another when a push button is operated.
- C. Each zone shall be configurable to control the following light sources:
1. Non-dimmed loads.
 2. LED lamps.
 3. 0-10V dimming.
 4. DALI control.
 5. DMX control.
- D. Memory: Retain preset scenes and fade settings through power failures by retaining physical settings of controls.
- E. Master Station:
1. Controls and commands adjustment of each dimmer-zone setting for each scene change from one preset scene to another.
 - a. Master zone raises and lowers lighting level.
 - b. Adjustable fade rate for each scene from 1 to 60 seconds.
 2. Scene-select buttons.
 3. Lighting-level setting shall be graphically indicated.
 4. Mounting: Flush wall box with manufacturer's faceplate and custom labeling.

- F. LED Zone Dimmer: Via external 0-10V LED dimming module(s) for operating LED fixtures and arranged to dim number of scenes indicated for the master-scene controller. Scene selection shall be at the master-scene controller for setting light levels of each zone associated with scene.
 - 1. Electrical Rating: Power and voltage rating to match loads controlled.
 - 2. Voltage Regulation: Dimmer shall maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent in RMS voltage.

2.9 LOW VOLTAGE CONTROL INTERFACES

- A. Contact Closure Interfaces
 - 1. The contact closure input device will accept both momentary and maintained contact closures.
 - 2. The contact closure output device can be configured for maintained or pulsed outputs.
- B. RS232 and Ethernet Interface
- C. Provide ability to communicate via Ethernet or RS232 to audiovisual equipment, touch screens, etc.
- D. Provide control of:
 - 1. Lights scene selections.
 - 2. Shade Group Presets.
 - 3. Fine-tuning of shade preset or light scenes levels with raise/lower.
 - 4. Simulate system wall station button presses and releases.
- E. Provide status monitoring of:
 - 1. Light scene-status.
 - 2. Shade Group status.
 - 3. Wall station button presses and releases.
 - 4. Wall station LEDs.
- F. SENSORS
 - 1. Occupancy Sensors: Occupancy sensors shall be dual technology and compatible with the lighting management control system and addressable fixture control system.
 - 2. Daylight Sensors:
 - a. Interior Daylight Sensors: Sensors shall be compatible with the lighting management control system and addressable fixture control system.
 - 3. Exterior Daylight Sensors: Calibrated with independent turn-on and turn-off thresholds; minimum 2 foot-candles difference between the turn-on and turn-off thresholds. Enclosed in weatherproof housing with shading and lens protection visor.
 - 4. Infrared Partition Sensor: Provide contact closure based on status of the partition wall (open/close).

2.10 ACCESSORIES

- A. Emergency Lighting Interface.
 - 1. Provides total system listing to UL924 when used with lighting management system.
 - 2. Senses all three phases of building power.
 - 3. Provides an output to power panels or Digital Ballast Interfaces if power on any phase fails.
 - 4. Accepts a contact closure input from a fire alarm control panel.

2.11 SOURCE QUALITY CONTROL

- A. Perform full-function testing on all completed assemblies at end of line. Statistical sampling is not acceptable.
- B. Audit burn-in at 104° F ambient temperature of dimming assemblies and panels at full load for two hours.

PART 3 - EXECUTION

3.1 WIRING INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Install wiring within walls and inaccessible ceilings in raceways, provide backboxes for all wall mounted devices. Cables run above accessible ceilings may be supported by J-hooks. Route wiring within cable trays wherever possible. Comply with Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" and Section 27 10 00 "Structured Cabling Systems." Minimum conduit size shall be 3/4 inch.
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.
- D. Install field-mounting transient voltage suppressors for lighting control devices in Category A locations that do not have integral line-voltage surge protection.
- E. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
- F. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in terminal cabinets, equipment enclosures, and in junction, pull, and outlet boxes.
- G. Connections: 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.

- H. Provide dedicated neutral wiring (not shared between zones) where required per manufacturer recommendations for any control components.

3.2 EQUIPMENT INSTALLATION

- A. Ground all equipment with available grounding terminals.
- B. Ensure that all daylight and occupancy sensor placements follow manufacturer installation instructions, are approved by Architect, and are coordinated with ceiling fabrication and installation.
 - 1. Notify Architect of any discrepancies between manufacturer installation instructions and design drawings.

3.3 IDENTIFICATION

- A. Identify power and control wiring according to Section 26 05 53 "Identification for Electrical Systems".
- B. Label each system module with a unique designation corresponding to its identification in system software, server, operations and maintenance submittals, and diagnostic reports. Make designations on elevated components large enough and mount to be readable from floor

3.4 PRE-INSTALLATION MEETINGS

- A. Contractor shall schedule a meeting with Contractor, Owner, Architect, Lighting Designer, and Engineer to review sequence of operation schedule provided as part of the lighting control submittal. This meeting shall occur before commencing installation.
 - 1. Document decisions and update the comprehensive sequence of operations document based on meeting(s) above and distribute to Owner and Design Team.
- B. Contractor shall schedule a meeting on-site with the Contractor, Manufacturer, and Engineer to talk through and review the system prior to installation. This meeting shall occur after the submittal has been approved but before commencing installation.

3.5 MANUFACTURER SENSOR LAYOUT AND TUNING

- A. The manufacturer shall review and adjust the layout and tuning of all devices to obtain the sequence of operations as indicated on the drawings and specifications and to ensure coverage and correct operation of all devices within all spaces. The Contractor shall provide all additional devices as required by the manufacturer.

3.6 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 assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Test for circuit continuity.
 - 2. Verify that the control module features are operational.
 - 3. Check operation of local override controls.
 - 4. Check operation and time delays of vacancy and occupancy sensors. Confirm all sensors operate as specified on the drawings.
 - 5. Check operation of all daylight sensors. Confirm light levels on working surfaces are as indicated in the sequence of operations at varying daylight levels.
 - 6. Test system diagnostics by simulating improper operation of several components selected by Architect.
 - 7. Operational Test: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.
 - 8. Emergency Power Transfer: Test listed functions.
- C. Remove and replace malfunctioning control components and retest as specified above.
 - 1. Reports: Submit written reports recording defective materials and workmanship, unsatisfactory test results, repairs and adjustments, and final test results.
- D. Daylighting: Program interior daylight sensor setpoints for each daylight zone according to illuminance criteria as directed by Architect for each room type, and distance from window. Using calibrated handheld meter(s), for each daylight sensor, verify each related lighting zone dims to the minimum level or off when the daylight level within that zone reaches the illuminance setpoint. Assume a unique daylight setpoint for at least three different daylight zones per interior daylight sensor throughout project.
- F. Provide report documenting testing and verification of each daylight zone setpoint, indicating date and time of each daylight sensor test, position of handheld meter for each test, and illuminance reading on meter at which lights dimmed to minimum or off.
 - 1. Provide manufacturer technician time on site for testing and programming until all documentation of daylight sensors function matches criteria as directed at the time of programming commencement.
- G. Perform the following with the help of the Manufacturer's field service technician. Visits shall be both daytime and after-hours visits as required to ensure correct functionality of the system as indicated in the sequence of operations.

1. Sensor layout and tuning.
2. Onsite scene and level tuning.
3. System performance-verification documentation
4. Onsite performance-verification walkthrough

3.7 SOFTWARE INSTALLATION

- A. Install and program software with initial settings of adjustable values. Make backup copies of software and user-supplied values. Provide current licenses for software.

3.8 COMMISSIONING

- A. Provide commissioning per commissioning specification, and as described here-in.
 1. Review comprehensive sequence of operation schedule and request any outstanding information from Owner and Design Team.
 2. Update the comprehensive sequence of operations document based on information received and distribute to Owner and Design Team.
 3. Test all lighting control equipment to ensure operation consistent with specifications. Testing shall include verification of proper operation of all equipment for light level and time functions.
 4. Make adjustments as necessary and repeat test until required function is achieved.
 5. Provide commissioning report showing how the system was commissioned and what settings were used to Owner and Commissioning Agent.
- B. At a minimum, the Manufacturer or Manufacturer's Representative shall be present at the first two project commissioning meetings.

3.9 ADVANCED PROGRAMMING

- A. Factory trained personnel (Programmer), familiar with the installed system(s), shall be provided for the purposes of executing programming services to meet specified requirements.
- B. The Programmer, at the direction of the Lighting Consultant and/or Owner's Representative, will adjust all programmable components of the lighting and control system to meet the design intent of the project.
- C. The Programmer will be factory trained and will hold current certification for all furnished control systems. Re-certification for Programmers will be required at least every five (5) years.

3.10 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance with support from the Manufacturer or

Manufacturer's Representative in adjusting sensors and to assist Owner's personnel in making program changes to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

3.11 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, program, and maintain lighting controls. Refer to Section 01 79 00 "Demonstration and Training."

END OF SECTION

SECTION 26 09 93

LIGHTING CONTROL SEQUENCE OF OPERATIONS

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- 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 SUMMARY

- A. This section includes control sequences for lighting control systems, subsystems, and equipment.

1.3 RELATED SECTIONS:

- A. Consult all other Sections, determine the extent and character of related work and properly coordinate work specified herein with that specified elsewhere to produce a complete installation.
 - 1. Section 01 91 14 – MEP Commissioning Requirements
 - 2. Section 26 05 53 – Identification for Electrical Systems
 - 3. Section 26 06 50 – Schedules for Lighting
 - 4. Section 26 09 43 – Network Lighting Controls

1.4 DESCRIPTION OF WORK

- A. Control sequences are hereby defined as the manner and method by which automatic and manual lighting controls function. Requirements for each type of operation are specified in this section.
- B. Operating equipment, devices, and system components required for control systems are specified in other Division 26 sections of these specifications.
- C. Provide all equipment, devices, and system components required to accomplish the control sequences described in this section. Equipment, devices, and system components not specified in other Division 26 sections but necessary to accomplish the sequences specified in this division shall be provided.
- D. All efforts have been made to identify where individual functions will overlap and identify what the desired functionality is during such overlaps. Additional overlaps

discovered during installer's development of the system shall be brought to the immediate attention of the Architect/Engineer.

- E. See drawings for more information on the following:
 - 1. Lighting floor plans (E4-XX series) indicate placement of switches, occupancy sensors, and photosensors.
 - 2. Lighting floor plans (E4-XX series) indicate luminaire circuiting and/or lighting control system relay identifier.
 - 3. Lighting schematics (E3-1X series) indicate rough equipment types and typical wiring interconnections. Exact quantities and locations of all switches, photo and occupancy sensors are shown on the floor plans (E4-XX series). The Contractor is responsible for providing all power packs, wireless transmitters and receivers, dimming and relay panels, additional power circuits, phase-loss monitors, fire alarm, BAS interfaces, etc. as required to meet the intent of the sequence of operations.

1.5 DEFINITIONS

- A. Astronomic timeclock: A timeclock allowing control of loads based on clock time as well as astronomic time events such as sunrise and sunset, based on project latitude.
- B. BAS: Building Automation System
- C. Control station: A single coverplate containing multiple switches or buttons for control of lighting and/or equipment.
- D. Daylight response: For those luminaires within the daylit zone of a particular area, the luminaires shall continually adjust in response to the presence of daylight.
- E. Delay warning: A warning consisting of lights in a particular area turning off and immediately back on again to notify occupants of impending automatic shutoff. Occurs a preset amount of time prior to lights being automatically turned off by the LCP.
- F. Key Switch: A switch (low or line voltage) operated with a key. Locks with fork-style keys or other non-cylinder locks are not acceptable.
- G. LCP: Lighting control panel consisting of microprocessor-controlled relays which may consist of a single panel or multiple panels linked by a data connection to function as a single system.
- H. Local switching: Line voltage switching, which may be downstream of other control devices, providing on/off control of groups of lighting fixtures.
- I. Low-voltage input: A low-voltage device communicating back to the lighting control system. May be utilized to provide manual control of some control functions. May be a momentary contact switch or button, multi-button station, toggle switch, key switch, paddle switch, or other device depending on device configuration.

- J. Pushbutton: All pushbuttons shall contain an LED indicating the current status of the controlled lighting/loads.
- K. Manual Operation: User-activated control of lighting (on, off, scene selection, or dimmed) from a wall switch or push button. Depending on placement in operation hierarchy, may override or be overridden by other controls.
- L. Occupancy sensor on: Automatically turns on lighting, based on sensed motion.
- M. Occupancy sensor off: Automatic shut-off of lighting by occupancy sensor, based on sensed motion. If no motion has been sensed for a user-adjustable period of time of up to 30 minutes, the lights will turn off.
- N. Override: A time-limited override function initiated manually at a control station for the purpose of turning on lights after normal operating hours. The associated lights turn off automatically at the end of a timed period. The length of the timed period shall be user-programmable. The associated lights shall provide a delay warning five minutes (programmable between 1 and 30 minutes) before the timed period expires.
- O. Relay: A device controlled by the LCP providing on-off control of a load.
- P. Set Points: Variables within the lighting control systems that determine functionality. All system set points shall be individually adjustable via programming or physical adjustment unless specifically noted. Examples of set points:
 - 1. Clock time (i.e. 7pm)
 - 2. Astronomic time (i.e. $T = \text{sunset} + 30 \text{ minutes}$)
 - 3. Photocell threshold level (i.e. 50 footcandles)
 - 4. Delay warning time setback (i.e. 5 minutes before OFF command)
- Q. TOD: Time of day switching, based on clock time, calendar date, holiday schedule, special event schedule. Completely software-defined, independent from each other and programmable automatic function.
- R. Time delay: An adjustable delay of time that shall pass prior to device-initiated action.
- S. Vacancy sensor off: Automatic shut-off of lighting by vacancy sensor, based on sensed motion. If no motion has been sensed for a user-adjustable period of time of up to 30 minutes, the lights will turn off. Lighting in this space are switched on manually.
- T. Wall control: A line voltage switch or low voltage input located on the wall for local user control.

1.6 GENERAL

- A. Light levels noted are average light levels, in footcandles (fc), at the level of the workplane (30" (762 mm) AFF) except in corridors, where light levels are noted at floor level.

- B. Where wall controls are shown adjacent to each other on drawings, they shall be grouped under a common cover plate wherever possible to create a control station as defined above.
- C. It is the Contractor's responsibility to determine trim/dimming settings to reach the design criteria footcandle light levels indicated for each space. The Contractor/Vendor is responsible for coordinating actual fixture performance and dimming curve with the lighting control system and required setpoints.

PART 2 - PRODUCTS – NOT USED.

PART 3 - EXECUTION

3.1 GENERAL

- A. The functionality of the system as described below shall be achievable as a whole. Conflicts between programming of different time schedule, priority levels between different programs, etc. shall be resolved to achieve the programming below without limitation.
- B. General system function:
 - 1. System shall control lighting as indicated in the following sequence of operations for each space. It is the Contractor's responsibility to provide a complete and functional lighting control system per the sequence of operations. The Contractor is responsible for providing all hardware, wiring, software, programming, connections, etc. as which may be required, based on the selected system, to meet the control intent included in the drawings and specifications.
 - 2. All spaces shall be fully networked as part of the lighting control system unless otherwise noted.
 - 3. All spaces shall conform to local energy code compliance requirements for operation.
 - 4. Wall controls, photosensors, and occupancy/vacancy sensors providing input to the LCP shall be capable of being replaced without system reprogramming.
 - 5. Where multiple occupancy/vacancy sensors are shown in a single room, input to a single sensor shall control all lights in room, unless otherwise noted by zones indicated next to sensor or in this sequence of operations.
 - 6. Photosensors shall be of the continuous dimming type.
 - 7. Provide lighting control zones by area, with each fixture type in a space allocated a unique control zone.

3.2 EMERGENCY LIGHTING

- A. Emergency lighting is via generator except where noted otherwise. Normal operation of emergency lighting shall be identical to adjacent non-emergency lighting unless otherwise noted. On loss of normal power, all emergency luminaires shall immediately illuminate to full brightness.

- B. On return of normal power, all luminaires in areas connected to networked lighting control system shall resume their state previous to the power loss.
- C. On return of normal power, all luminaires in areas being controlled by occupancy sensors shall resume control via occupancy sensor (they will remain off until new sensing of movement is detected).
- D. All emergency lighting shall be programmed to turn on to full brightness upon low-voltage signal from the fire alarm system in addition to all functionality indicated below.
- E. Where supplemental emergency lighting has been provided via local battery powered fixtures this lighting shall be connected to the local emergency lighting circuit to operate in the case of a failure of generator powered emergency lighting within the space.

3.3 BAS INTEGRATION

- A. The system headend shall support BACnet over IP for communication with the BAS. The lighting control system shall report occupancy status for each space to the BAS regardless of current lighting set point. The Contractor is responsible for providing all PIC statements, programming time, coordination time, etc. as may reasonably be required to facilitate the interconnection with the BAS system. The Contractor and Lighting Control System vendor is responsible for meeting and coordinating with the BAS Contractor prior to starting any installation work.

3.4 FIRE ALERTING SYSTEM INTEGRATION

- A. The system headend shall support integration for communication with the Fire Alerting System. The Contractor is responsible for providing all programming time, coordination time, etc. as may reasonably be required to facilitate the interconnection with the Fire Alerting system. The Contractor and Lighting Control System vendor is responsible for meeting and coordinating with the Fire Alerting System Vendor/Contractor prior to starting any installation work.

3.5 SEQUENCE OF OPERATIONS

- A. Time Schedule: For time schedule events, use the following regularly scheduled times, programmable by Owner through the lighting control system:
 - 1. MORNING: daily 5:30 AM
 - 2. DAY: daily, Sunrise
 - 3. EVENING: daily, Sunset
 - 4. OVERNIGHT: daily, 11:30 PM
 - 5. SUNSET and SUNRISE as calculated by astronomical time clock
- B. Lighting set points and sensor timeouts indicated shall be globally re-programmable for each control type listed below, in that a single setting change will update the high-end and/or low-end lighting trim for all spaces of a similar control type. In

addition, override of individual spaces shall be possible. All such high/low end trim adjustments shall be possible from the central system PC.

- C. Where daylighting is indicated as REQUIRED, the following shall be true:
1. Primary and Secondary daylit perimeter fixtures where photosensors are shown on drawings. Footcandle levels shall be programmed to maintain ambient light levels per the indicated set points. Primary and Secondary daylit fixtures shall be dimmed by the photosensor separately and independent from the interior fixtures. The manual control shall adjust all lights (up to the maximum setpoint for the daylit fixtures based on the current ambient conditions).

3.6 SEQUENCE OF OPERATIONS FOR SPECIFIC AREAS

A. Offices, meeting rooms:

	Notes
Lights Included	All fixtures excluding task lights. Fixtures are dimmed.
Timeclock	None.
Occupancy/vacancy operation	Fixtures operate with Vacancy detection.
Manual operation	Keypads shall include ON/OFF/RAISE/LOWER control. Where applicable provide dual gang plate to incorporate shade controls.
Daylighting	REQUIRED where applicable.
Emergency	Upon loss of power to any normal circuit within the same room, or by initiation from the fire alarm system all emergency lighting goes to 100%.
Controlled receptacles	Occupant sensor control that shall turn off receptacles within 20 minutes of all occupants leaving a space. Receptacles turn off after time delay once space is vacant. Receptacles are controlled separately on a space by space basis.
Set points	ON setting – 30FC OFF setting – OFF VACANCY time delay – 15 mins

B. General applications:

	Notes
Lights Included	All fixtures excluding task lights. Fixtures are dimmed.
Timeclock	None.
Occupancy/vacancy operation	Fixtures operate with Occupancy detection where sensors shown on plan.
Manual operation	Standalone Task lights (if/where applicable) within the space shall have integrated ON/OFF control. Keypads shall include ON/OFF/RAISE/LOWER control per zone.
Daylighting	REQUIRED where applicable.
Emergency	Upon loss of power to any normal circuit within the same room, or by initiation from the fire alarm system all emergency lighting goes to 100%.
Controlled receptacles	Not applicable.
Set points	ON setting – 30FC OFF setting – OFF VACANCY time delay – 15 mins

C. Electrical, Mechanical rooms etc:

	Notes
Lights Included	All fixtures. Fixtures are dimmed.
Timeclock	None.
Occupancy/vacancy operation	None.
Manual operation	All keypads indicated within the space shall have an ON/OFF toggle button.
Daylighting	None.
Emergency	Upon loss of power to any normal circuit within the same room, or by initiation from the fire alarm system all emergency lighting goes to 100%. Where battery lighting units are shown, they shall be connected to unswitched Emergency lighting circuits and shall illuminate upon loss of Emergency power.
Controlled receptacles	None.
Set points	None.

D. Small storage, closet, individual restrooms etc:

	Notes
Lights Included	All fixtures. Fixtures are dimmed.
Timeclock	None.
Occupancy/vacancy operation	Lights operate in OCCUPANCY operation. Lights turn ON when space is occupied and OFF after time delay once space is vacant.

Manual operation	Where applicable (Via sensor switch).
Daylighting	None.
Emergency	Upon loss of power to any normal circuit within the same room, or by initiation from the fire alarm system all emergency lighting goes to 100%.
Controlled receptacles	None.
Set points	VACANCY time delay – 15 mins

E. Additional Spaces

1. Refer to drawings for additional sequence of operations for select spaces

END OF SECTION 260993

SECTION 26 12 19

PAD-MOUNTED, LIQUID-FILLED, MEDIUM-VOLTAGE TRANSFORMERS

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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 pad-mounted, liquid-filled, medium-voltage distribution transformers, with primary and secondary bushings within or without air-terminal enclosures.

1.3 DEFINITIONS

- A. BIL: Basic Impulse Insulation Level.
- B. Bushing: An insulating structure including a central conductor, or providing a central passage for a conductor, with provision for mounting on a barrier, conducting or otherwise, for the purpose of insulating the conductor from the barrier and conducting current from one side of the barrier to the other.
- C. Bushing Elbow: An insulated device used to connect insulated conductors to separable insulated connectors on dead-front, pad-mounted transformers and to provide a fully insulated connection. This is also called an "elbow connector."
- D. Bushing Insert: That component of a separable insulated connector that is inserted into a bushing well to complete a dead-front, load break or nonload break, separable insulated connector (bushing).

- E. Bushing Well: A component of a separable insulated connector, either permanently welded or clamped to an enclosure wall or barrier, having a cavity that receives a replaceable component (bushing insert) to complete the separable insulated connector (bushing).
- F. Elbow Connector: See "bushing elbow" above.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For pad-mounted, liquid-filled, medium-voltage transformers.
 - 1. Include plans and elevations showing major components and features.
 - a. Include a plan view and cross section of equipment base, showing clearances, required workspace, and locations of penetrations for grounding and conduits.
 - 2. Include details of equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include single-line diagram.
 - 4. Include list of materials.
 - 5. Include nameplate data.
 - 6. Manufacturer's published time-current curves of the transformer high-voltage fuses, with transformer damage curve, inrush curve, and thru fault current indicated.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings:

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1. Utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement.
 - B. Qualification Data: For testing agency.
 - C. Seismic Qualification Certificates: For transformer assembly, 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.
 - D. Product Certificates: For transformers, signed by product manufacturer.
 - E. Source quality-control reports.
 - F. Field quality-control reports.
- 1.6 CLOSEOUT SUBMITTALS
- A. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.
- 1.7 QUALITY ASSURANCE
- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

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. Comply with IEEE C2.
- C. Comply with IEEE C57.12.00.

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: The 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 and the transformer will be fully operational after the seismic event."
 - 2. Component Importance Factor: 1.5.
 - 3. Component Amplification Factor: 2.5.
 - 4. Component Response Modification Factor: 3.0.
- B. Windings Material: Aluminum.
- C. Surge Arresters: Comply with IEEE C62.11, Distribution Class; metal-oxide-varistor type, fully shielded, separable-elbow type, suitable for plugging into the inserts provided in the high-voltage section of the transformer. Connected in each phase of incoming circuit and ahead of any disconnecting device.
- D. Winding Connections: The connection of windings and terminal markings shall comply with IEEE C57.12.70.
- E. Efficiency: Comply with 10 CFR 431, Subpart K.
- F. Insulation: Transformer kVA rating shall be as follows: The average winding temperature rise above a 30 deg C ambient temperature shall not exceed 65 deg C

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and 80 deg C hottest-spot temperature rise at rated kVA when tested according to IEEE C57.12.90, using combination of connections and taps that give the highest average winding temperature rise.

- G. Tap Changer: External handle, for de-energized operation.
- H. Tank: Sealed, with welded-on cover. Designed to withstand internal pressure of not less than 7 psi (50 kPa) without permanent distortion and 15 psig (104 kPa) without rupture. Comply with IEEE C57.12.36.
- I. Enclosure Integrity: Comply with IEEE C57.12.28 for pad-mounted enclosures that contain energized electrical equipment in excess of 600 V that may be exposed to the public.
- J. Mounting: An integral skid mounting frame, suitable to allow skidding or rolling of transformer in any direction, and with provision for anchoring frame to pad.
- K. Insulating Liquids:
 - 1. Less-Flammable Liquids:
 - a. Edible-Seed-Oil-Based Dielectric: Listed and labeled by an NRTL as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D92. Liquid shall be biodegradable and nontoxic, having passed the Organisation for Economic Co-operation and Development G.L.203 with zero mortality, and shall be certified by the U.S. Environmental Protection Agency as biodegradable, meeting Environmental Technology Verification requirements.
 - b. Biodegradable and Nontoxic Dielectric: Listed and labeled by an NRTL as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D92.
- L. Sound level shall comply with NEMA TR 1 requirements.
- M. Corrosion Protection:
 - 1. Transformer coating system shall be factory applied, complying with requirements of IEEE C57.12.28, in manufacturer's standard color green.
 - 2. Fabricate front sill, hood, and tank base of single-compartment transformers from stainless steel according to ASTM A167, Type 304 or 304L, not less than

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No. 13 U.S. gage, complying with requirements of IEEE C57.12.28, standard color green.

3. Base and Cabinets of Two Compartment Transformers: Fabricate from stainless steel according to ASTM A167, Type 304 or 304L, not less than No. 13 U.S. gage. Coat transformer with manufacturer's standard green color coating complying with requirements of IEEE C57.12.28, in manufacturer's standard color green.

2.3 THREE-PHASE TRANSFORMERS

A. Manufacturers:

1. Eaton (Cooper Power)
2. Hitachi Energy
3. Schneider Electric
4. ABB, Inc.

B. Description:

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 application.
2. Comply with IEEE C57.12.26.

C. Compartment Construction:

1. Single-Compartment Construction: Clamshell style, with provision for padlocking, hinged cover, and single-point latching.
2. Double-Compartment Construction: Individual compartments for high- and low-voltage sections, formed by steel isolating barriers that extend full height and depth of compartments, with hinged, lift-off doors and three-point latching, with a stop in the open position and provision for padlocking.

D. Primary Fusing: Designed and rated to provide thermal protection of transformer by sensing overcurrent and high liquid temperature.

1. 150-kV BIL current-limiting fuses, conforming to requirements of IEEE C37.47.
2. Interrupting Rating: 50,000 rms A symmetrical at system voltage.
3. Fuse Assembly: Bayonet-type, liquid-immersed, expulsion fuses in series with liquid-immersed, partial-range, current-limiting fuses. Bayonet fuse shall sense both high currents and high oil temperature to provide thermal protection to the transformer. Connect current-limiting fuses ahead of radial-feed load-break switch.
4. Provide bayonet fuse assembly with an oil retention valve and an external drip shield inside the housing to eliminate or minimize oil spills. Valve shall close when fuse holder is removed and an external drip shield is installed.
5. Provide a conspicuously displayed warning adjacent to bayonet fuse(s), cautioning against removing or inserting fuses unless transformer has been de-energized and tank pressure has been released.

E. High-Voltage Section: Dead-front design.

1. To connect primary cable, use separable insulated connectors; coordinated with and complying with requirements of Section 26 05 13 "Medium-Voltage Cables." Bushings shall be one-piece units, with ampere and BIL ratings the same as connectors.
2. Bushing inserts and feed-through inserts:
 - a. Conform to the requirements of IEEE 386.
 - b. Rated at 200 A, with voltage class matching connectors. Provide a parking stand near each bushing well. Parking stands shall be equipped with insulated standoff bushings for parking of energized load-break elbow connectors on parking stands.
 - c. Provide insulated protective caps for insulating and sealing out moisture from unused bushing inserts and insulated standoff bushings.
3. Bushing wells configured for loop-feed application.

4. Access to liquid-immersed fuses.
5. Dead-front surge arresters.
6. Tap-changer operator.
7. Load-Break Switch:
 - a. Radial-feed, liquid-immersed type with voltage class and BIL matching that of separable connectors, with a continuous current rating and load-break rating of 200 amperes, and a make-and-latch rating of 12 kA rms symmetrical.
 - b. Loop-feed sectionalizing switches, using three two-position, liquid-immersed-type switches for closed transition loop-feed and sectionalizing operation. Voltage class and BIL shall match that of separable connectors, with a continuous current rating and load-break rating of 200 amperes, and a make-and-latch rating of 12 kA rms symmetrical. Switch operation shall be as follows:
 - 1) Position I: Line A connected to line B and both lines connected to the transformer.
 - 2) Position II: Transformer connected to line A only.
 - 3) Position III: Transformer connected to line B only.
 - 4) Position IV: Transformer disconnected and line A not connected to line B.
 - 5) Position V: Transformer disconnected and line A connected to line B.
8. Ground pad.

F. Low-Voltage Section:

1. Bushings with spade terminals drilled for terminating the number of conductors indicated on the Drawings, and the lugs that comply with requirements of Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

G. Capacities and Characteristics:

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1. Power Rating (kVA): As indicated on drawings.
2. Voltage Ratings: As indicated on drawings.
3. Taps: Comply with IEEE C57.12.26 requirements; provide $\pm 2 \times 2.5$ percent (four total taps), de-energized no-load tap changer (DNLT), unless otherwise indicated.
4. Transformer BIL (kV): Comply with IEEE C57.12.26 requirements; minimum BIL = 95 kV for 15 kV class.
5. Minimum Tested Impedance (Percent at 85 deg C): Provide impedance consistent with IEEE C57.12.26 for the specified kVA rating; minimum impedance = 4.03 for 1000-2500 kVA.
6. K-factor: K-1, complying with UL 1562.
7. Comply with FM Global Class No. 3990.
8. Comply with UL listing requirements for combination classification and listing for transformer and less-flammable insulating liquid.

H. Transformer Accessories:

1. Drain and filter connection.
2. Filling and top filter press connections.
3. Pressure-vacuum gauge.
4. Dial-type analog thermometer with alarm contacts.
5. Magnetic liquid level indicator with high and low alarm contacts.
6. Automatically resetting pressure-relief device. Device flow shall be as recommended by manufacturer. With alarm contacts and a manual bleeder.
7. Stainless-steel ground connection pads.
8. Machine-engraved nameplate, made of anodized aluminum or stainless steel.
9. Sudden pressure relay for remote alarm or trip when internal transformer pressure rises at field-set rate. Provide with seal-in delay.

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2.4 SERVICE CONDITIONS

- A. Transformers shall be suitable for operation under service conditions specified as usual service conditions in IEEE C57.12.00, except for the following:
1. Altitudes above 3300 feet (1000 m).
 2. Cooling air temperature exceeds limits.
 3. Excessive load current harmonic factor.
 4. Operation above rated voltage or below rated frequency.
 5. Exposure to explosive environments.
 6. Exposure to fumes, vapors, or dust.
 7. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.
 8. Exposure to seismic shock or to abnormal vibration, shock, or tilting.
 9. Exposure to excessively high or low temperatures.
 10. Unusual transportation or storage conditions.
 11. Unusual grounding resistance conditions.

2.5 CONTROL NETWORK

- A. Controllers: Support serial MS/TP and Ethernet IP communications, and able to communicate directly via RS-485 serial networks and Ethernet 10Base-T networks as a native device.

2.6 WARNING LABELS AND SIGNS

- A. Comply with requirements for labels and signs specified in Section 26 05 53 "Identification for Electrical Systems."
1. High-Voltage Warning Label: Provide self-adhesive warning signs on outside of high-voltage compartment door(s). Sign legend shall be "DANGER HIGH
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VOLTAGE" printed in two lines of nominal 2-inch- (50-mm)-)high letters. The word "DANGER" shall be in white letters on a red background and the words "HIGH VOLTAGE" shall be in black letters on a white background.

2. Arc Flash Warning Label: Provide self-adhesive warning signs on outside of high-voltage compartment door(s), warning of potential electrical arc flash hazards and appropriate personal protective equipment required.

2.7 SOURCE QUALITY CONTROL

- A. Provide manufacturer's certificate that the transformer design tests comply with IEEE C57.12.90.

1. Perform the following factory-certified routine tests on each transformer for this Project:
 - a. Resistance.
 - b. Turns ratio, polarity, and phase relation.
 - c. Transformer no-load losses and excitation current at 100 percent of ratings.
 - d. Transformer impedance voltage and load loss.
 - e. Operation of all devices.
 - f. Lightning impulse.
 - g. Low frequency.
 - h. Leak.
 - i. Transformer no-load losses and excitation current at 110 percent of ratings.
 - j. Insulation power factor.
 - k. Applied potential, except that this test is not required for single-phase transformers or for three-phase Y-Y-connected transformers.
 - l. Induced potential.
 - m. Resistance measurements of all windings on rated voltage connection and at tap extreme connections.
 - n. Ratios on rated voltage connection and at tap extreme connections.

- o. Polarity and phase relation on rated voltage connection.
- p. No-load loss at rated voltage on rated voltage connection.
- q. Exciting current at rated voltage on rated voltage connection.
- r. Impedance.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine pad-mounted, liquid-filled, medium-voltage transformers upon delivery.
 - 1. Upon delivery of transformers and prior to unloading, inspect equipment for any damage that may have occurred during shipment or storage.
 - 2. Verify that tie rods and chains are undamaged and tight, and that all blocking and bracing is tight. Verify that there is no evidence of load shifting in transit, and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.
 - 3. Verify that there is no indication of external damage and no dents or scratches in doors and sill, tank walls, radiators and fins, or termination provisions.
 - 4. Verify that there is no evidence of insulating-liquid leakage on transformer surfaces, at weld seams, on high- or low-voltage bushing parts, and at transformer base.
 - 5. Verify that there is positive pressure or vacuum on tank. Check pressure gauge; it is required to read other than zero.
 - 6. Compare transformers and accessories received with bill of materials to verify that shipment is complete. Verify that transformers and accessories conform with manufacturer's quotation and shop drawings. If shipment is incomplete or does not comply with Project requirements, notify manufacturer in writing immediately.
 - 7. Verify presence of polychlorinated biphenyl content labeling.

8. Unload transformers carefully, observing all packing label warnings and handling instructions.
9. Open termination compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.

B. Handling:

1. Handle transformers carefully, in accordance with manufacturer recommendations, to avoid damage to enclosure, termination compartments, base, frame, tank, and internal components. Do not subject transformers to impact, jolting, jarring, or rough handling.
2. Protect transformer termination compartments against entrance of dust, rain, and snow.
3. Transport transformers upright, to avoid internal stresses on core and coil mounting assembly and to prevent trapping air in windings. Do not tilt or tip transformers.
4. Verify that transformer weights are within rated capacity of handling equipment.
5. Use only manufacturer-recommended points for lifting, jacking, and pulling. Use all lifting lugs when lifting transformers.
6. Use jacks only at corners of tank base plate.
7. Use nylon straps of same length to balance and distribute weight when handling transformers with a crane.
8. Use spreaders or a lifting beam to obtain a vertical lift and to protect transformer from straps bearing against enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.
9. Exercise care not to damage tank base structure when handling transformer using skids or rollers. Use skids to distribute stresses over tank base when using rollers under large transformers.

C. Storage:

1. Store transformers in accordance with manufacturer's recommendations.
 2. Transformers may be stored outdoors. If possible, store transformers at final installation locations on concrete pads. If dry concrete surfaces are unavailable, use pallets of adequate strength to protect transformers from direct contact with ground. Ensure transformer is level.
 3. Ensure that transformer storage location is clean and protected from severe conditions. Protect transformers from dirt, water, contamination, and physical damage. Do not store transformers in presence of corrosive or explosive gases. Protect transformers from weather when stored for more than three months.
 4. Store transformers with compartment doors closed.
 5. Regularly inspect transformers while in storage and maintain documentation of storage conditions, noting any discrepancies or adverse conditions. Verify that an effective pressure seal is maintained using pressure gauges. Visually check for insulating-liquid leaks and rust spots.
- D. Examine areas and space conditions for compliance with requirements for pad-mounted, liquid-filled, medium-voltage transformers and other conditions affecting performance of the Work.
- E. Examine roughing-in of conduits and grounding systems to verify the following:
1. Wiring entries comply with layout requirements.
 2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will cross section barriers to reach load or line lugs.
- F. Examine concrete bases for suitable conditions for transformer installation.
- G. Pre-Installation Checks:
1. Verify removal of any shipping bracing after placement.
 2. Remove a sample of insulating liquid according to ASTM D923. Insulating-liquid values shall comply with NETA ATS, Table 100.4. Sample shall be tested for the following:

- a. Dielectric Breakdown Voltage: ASTM D877 or ASTM D1816.

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- b. Acid Neutralization Number: ASTM D974.
 - c. Specific Gravity: ASTM D1298.
 - d. Interfacial Tension: ASTM D971.
 - e. Color: ASTM D1500.
 - f. Visual Condition: ASTM D1524.
 - g. Water in Insulating Liquids: Comply with ASTM D1533.
 - h. Power Factor or Dissipation Factor: ASTM D924.
- H. Verify that ground connections are in place and that requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at transformer location.
- I. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install transformers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 03 30 00 "Cast-in-Place Concrete."
- B. Transformer shall be installed level and plumb and shall tilt less than 1.5 degrees while energized.
- C. Comply with requirements for vibration isolation and seismic control devices specified in Section 26 05 29 "Hangers and Supports for Electrical Systems" and Section 26 05 48.16 "Seismic Controls for Electrical Systems."
- D. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and IEEE C2.

3.3 CONNECTIONS

- A. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."
- 1. For counterpoise, use tinned bare copper cable not smaller than No. 4/0 AWG, buried not less than 30 inches (765 mm) below grade interconnecting the grounding electrodes. Bond surge arrester and neutrals directly to

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transformer enclosure and then to grounding electrode system with bare copper conductors, sized as shown. Keep lead lengths as short as practicable, with no kinks or sharp bends.

2. Fence and equipment connections shall not be smaller than No. 4 AWG. Ground fence at each gate post and corner post and at intervals not exceeding 10 ft. (3050 mm). Bond each gate section to fence post using 1/8 by 1 inch (3 by 25 mm) tinned flexible braided copper strap and clamps.
 3. Make joints in grounding conductors and loops by exothermic weld or compression connector.
 4. Terminate all grounding and bonding conductors on a common equipment grounding terminal on transformer enclosure.
 5. Complete transformer tank grounding and lightning arrester connections prior to making any other electrical connections.
- B. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."
1. Maintain air clearances between energized live parts and between live parts and ground for exposed connections in accordance with manufacturer recommendations.
 2. Bundle associated phase, neutral, and equipment grounding conductors together within transformer enclosure. Arrange conductors such that there is not excessive strain that could cause loose connections. Allow adequate slack for expansion and contraction of conductors.
- C. Terminate medium-voltage cables in incoming section of transformers according to Section 26 05 13 "Medium-Voltage Cables."

3.4 SIGNS AND LABELS

- A. Comply with installation requirements for labels and signs specified in Section 26 05 53 "Identification for Electrical Systems."
- B. Install warning signs as required to comply with 29 CFR 1910.269.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

1. General Field-Testing Requirements:

- a. Comply with provisions of NFPA 70B Ch. "Testing and Test Methods."
- b. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
- c. After installing transformer but before primary is energized, verify that grounding system at the transformer is tested at specified value or less.
- d. After installing transformer and after electrical circuitry has been energized, test for compliance with requirements.
- e. Visual and Mechanical Inspection:
 - 1) Verify equipment nameplate data complies with Contract Documents.
 - 2) Inspect bolted electrical connections for high resistance using one of the following two methods:
 - a) Use a low-resistance ohmmeter to 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.
 - b) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In absence of manufacturer's published data, use NETA ATS, Table 100.12.
- f. Remove and replace malfunctioning units and retest.
- g. Prepare test and inspection reports. Record as-left set points of all adjustable devices.

2. Medium-Voltage Surge Arrester Field Tests:

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- a. Visual and Mechanical Inspection:
 - 1) Inspect physical and mechanical condition.
 - 2) Verify arresters are clean.
 - 3) Verify that ground lead on each device is individually attached to a ground bus or ground electrode.
 - b. Electrical Test:
 - 1) Perform an insulation-resistance test on each arrester, phase terminal-to-ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to comply with recommended minimum insulation resistance listed in that table.
 - 2) Perform a watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.
3. Liquid-Filled Transformer Field Tests:
- a. Visual and Mechanical Inspection:
 - 1) Test dew point of tank gases if applicable.
 - 2) Inspect anchorage, alignment, and grounding.
 - 3) Verify bushings are clean.
 - 4) Verify that alarm, control, and trip settings on temperature and level indicators are set and operate within manufacturer's recommended settings.
 - 5) Verify that liquid level in tanks is within manufacturer's published tolerances.
 - 6) Perform specific inspections and mechanical tests recommended by manufacturer.
 - 7) Verify presence of transformer surge arresters and that their ratings are as specified.

- 8) Verify that as-left tap connections are as specified.

b. Electrical Tests:

- 1) 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.
- 2) Perform power-factor or dissipation-factor tests on all windings according to test equipment manufacturer's published data. Maximum winding insulation power-factor/dissipation-factor values shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.3.
- 3) Measure core insulation resistance at 500-V dc if the core is insulated and the core ground strap is removable. Core insulation-resistance values shall not be less than 1 megohm at 500-V dc.
- 4) Perform a power-factor or dissipation-factor tip-up test on windings greater than 2.5 kV.
- 5) Perform turns-ratio tests at tap positions. Turns-ratio test results shall not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
- 6) Perform an excitation-current test on each phase. The typical excitation-current test data pattern for a three-legged core transformer is two similar current readings and one lower current reading. Investigate and correct if test shows a different pattern.
- 7) Measure resistance of each winding at each tap connection, and record temperature-corrected winding-resistance values in the Operations and Maintenance Manual.
- 8) Perform an applied-voltage test on high- and low-voltage windings-to-ground. Comply with IEEE C57.12.91, Sections 10.2 and 10.9. This test is not required for single-phase transformers and for three-phase Y-Y-connected transformers.
- 9) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.

- 10) Remove a sample of insulating liquid according to ASTM D923, and perform dissolved-gas analysis according to IEEE C57.104 or ASTM D3612.

3.6 FOLLOW-UP SERVICE

- A. Voltage Monitoring and Adjusting: After Substantial Completion, if requested by Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:
 1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the outgoing section of each transformer. Use voltmeters with calibration traceable to the National Institute of Science and Technology standards and with a chart speed of not less than 1 inch (25 mm) per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during test period, is unacceptable.
 2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
 - a. Adjust transformer taps.
 - b. Prepare written request for voltage adjustment by electric utility.
 3. Retests: Repeat monitoring, after corrective action is performed, until satisfactory results are obtained.
 4. Report:
 - a. Prepare a written report covering monitoring performed and corrective action taken.
- B. Infrared Inspection: Perform survey during periods of maximum possible loading. Remove all necessary covers prior to inspection.
 1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of transformer's electrical power connections.

2. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1°C at 30°C.
3. Record of Infrared Inspection: Prepare a certified report that identifies testing technician and equipment used, and lists results as follows:
 - a. Description of equipment to be tested.
 - b. Discrepancies.
 - c. Temperature difference between area of concern and reference area.
 - d. Probable cause of temperature difference.
 - e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
 - f. Identify load conditions at time of inspection.
 - g. Provide photographs and thermograms of deficient area.
4. Act on inspection results according to recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

3.7 DEMONSTRATION

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

END OF SECTION

SECTION 26 13 23

MEDIUM-VOLTAGE, METAL-ENCLOSED SWITCHGEAR

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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 outdoor metal-enclosed interrupter switchgear.

1.3 DEFINITIONS

- A. BIL: Basic Impulse Insulation Level.
- B. SCADA: Supervisory control and data acquisition.
- C. VRLA: Valve-regulated, recombinant, lead-calcium acid.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
 - 2. Time-current characteristic curves for overcurrent protective devices.
- B. Shop Drawings: For medium-voltage, metal-enclosed switchgear.
 - 1. Include a tabulation of installed devices with features and ratings.
 - 2. Include dimensioned plans and elevations, showing dimensions, shipping sections, and weights of each assembled section. Elevations shall show major components, features, and mimic bus diagram.
 - 3. Include a plan view and cross section of equipment base showing clearances, manufacturer's recommended work space, and locations of penetrations for grounding and conduits. Show location of anchor bolts and leveling channels.

4. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, and location and size of each field connection.
5. Locate accessory and spare equipment storage.
6. Include single-line diagram.
7. Include control power wiring diagrams.
8. Include copy of nameplate.
9. Ratings of the assembled switchgear:
 - a. Voltage.
 - b. Continuous current.
 - c. Short-circuit rating.
 - d. BIL.
10. Utility company's metering provisions with indication of approval by utility company.
11. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting seismic restraints.
12. Inters.
13. Wiring Diagrams: For each switchgear assembly include the following:
 - a. Power, signal, and control wiring.
 - b. Three-line diagrams of current and future secondary circuits showing device terminal numbers and internal diagrams.
 - c. Schematic control diagrams.
 - d. Diagrams showing connections of component devices and equipment.
 - e. Schematic diagrams showing connections to remote devices.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Outdoor Installations:
 - a. Utilities site plan, drawn to scale, showing heavy equipment or truck access paths for maintenance and replacement.
 - b. Dimensioned concrete base, outline of the switchgear, conduit entries, and grounding equipment locations.
2. Indoor Installations:
 - a. Dimensioned concrete base, outline of the switchgear, conduit entries, and grounding equipment locations.
 - b. Support locations, type of support, and weight on each support. Locate structural supports for structure-supported raceways, cable trays, and seismic anchors.
 - c. Location of lighting fixtures, sprinkler piping and heads, ducts, and diffusers.

- B. Qualification Data: For professional engineer and testing agency.
- C. Seismic Qualification Data: Certificates, for switchgear and control power, 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.
- D. Product Certificates: For switchgear, signed by product manufacturer.
- E. Source quality-control reports.
- F. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For switchgear and switchgear components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 "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.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below, before installation begins, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Spare Fuses: Six of each type and rating of fuse and fusible device used, except for medium-voltage fuses. Include spares for the following:
 - a. Primary disconnect fuses.
 - b. Potential transformer fuses.
 - c. Control power fuses.
 - d. Fuses and fusible devices for fused circuit breakers.
 - 2. Spare Indicating Lights: Six of each type installed.
 - 3. Primary Switch Contact Lubricant: One container(s).

1.8 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Accredited by NETA.
 - 1. Testing Agency's Field Supervisor: Certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in "Field Quality Control" Article.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Manufactured Unit: Metal-enclosed switchgear..
- B. Switchgear 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 IEEE C37.20.3.

2.2 MANUFACTURERS

- A. S&C Electric Company
- B. Eaton Corporation
- C. ABB Inc.

2.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: The switchgear shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means the switchgear will remain in place without separation of any parts when subjected to the seismic forces specified and the switchgear will be fully operational after the seismic event."
 - 2. Component Importance Factor: 1.5.
 - 3. Component Amplification Factor: 2.5.
 - 4. Component Response Modification Factor: 3.0.
- B. Service Conditions:
 - 1. Switchgear shall be suitable for operation under service conditions specified as usual service conditions in IEEE C37.20.3.

2.4 CONSTRUCTION

- A. To ensure a completely coordinated design, the metal-enclosed switchgear shall be constructed in accordance with the minimum construction specifications of the fuse and/or switch manufacturer to provide adequate electrical clearances and adequate space for fuse handling.
- B. Enclosure Construction
 - 1. In establishing the requirements for the enclosure design, consideration shall be given to all relevant factors such as controlled access; tamper resistance; corrosion resistance; protection from ingress of rodents, insects, and weeds; and the possibility of arcing faults within the enclosure.
 - 2. The enclosure of each bay shall be unitized monocoque construction to maximize strength, minimize weight, and inhibit corrosion.
 - 3. The material for all external sides of the enclosure and the roof shall be 11-gauge hot-rolled, pickled and oiled steel sheet.
 - 4. Each bay containing high-voltage components shall be a complete unit in itself, with full side sheets resulting in double-wall construction between bays. To guard against unauthorized or inadvertent entry, side and rear sheets and the top shall not be externally bolted.
 - 5. The base shall be a continuous steel channel of a thicker gauge material than used for the enclosure and shall extend completely around all four sides of each bay.
 - 6. Access to the interior of the enclosure shall be from the front only, allowing placement of the metal-enclosed switchgear assembly tight against a wall or back-to-back to minimize floor-space requirements.
 - 7. To guard against unauthorized or inadvertent entry, there shall be no access to high voltage through side or rear sheets of the metal-enclosed switchgear assembly; and no access to high voltage by means of externally removable panels.
 - 8. To guard against corrosion, all hardware (including door fittings, fasteners, etc.), all operating-mechanism parts, and other parts subject to abrasive action from mechanical motion shall be of either nonferrous materials, or galvanized or zinc-nickel-plated materials. Cadmium
 - 9. -plated ferrous parts shall not be used.
 - 10. Externally accessible hardware shall not be used for support of high-voltage components or switch-operating mechanisms within the switchgear.
- C. DOOR CONSTRUCTION
 - 1. Doors shall be constructed of 11-gauge hot-rolled, pickled, and oiled steel sheet.
 - 2. Doors shall have 90-degree flanges and shall overlap with the door openings. For strength and rigidity, and to minimize exposure, the door flanges shall be welded at the corners and shall be formed (at the top and both sides as a minimum) with a double bend so that the sheared-edge flanges at the top and both sides fold back parallel to the inside of the door. The double bend is not required on arc-resistant switchgear.
 - 3. Doors over 40 inches in height shall have a minimum of three concealed galvanized steel

4. or non-ferrous hinges with stainless-steel hinge pins. Doors 40 inches in height or less shall have a minimum of two such hinges.
5. Each door shall be equipped with a door handle. The door handle shall be padlockable and, on outdoor gear, shall incorporate a hood to protect the padlock shackle from tampering.
6. In consideration of controlled access, tamper resistance, and arcing faults, each door over 40 inches in height shall have a minimum of three concealed, interlocking, high-strength latches. Doors 40 inches in height or less shall have a minimum of two sure latches.
7. Doors providing access to interrupter switches or interrupter switches with power fuses shall be provided with a wide-view window, constructed of an impact-resistant material, to facilitate checking of switch position without opening the door.
8. Doors providing access to fuses or fused voltage transformers shall have provisions to store spare fuse units, refill units, or interrupting modules.
9. All doors providing access to high-voltage components shall be provided with a sturdy, self-latching door holder, which shall be zinc-nickel plated and chromate dipped.

D. ACCESS CONTROL

1. Doors providing access to interrupter switches with fuses shall be mechanically or key interlocked to guard against:
 - a. Opening the door if the interrupter switch on the source side of the fuse is closed, and
 - b. Closing the interrupter switch if the door is open.
2. Doors providing access to interrupter switches only, which are operated by stored-energy type switch operators, shall be mechanically interlocked to guard against operating the interrupter switch if the door is open.
3. Doors and hinged-bolted panels providing access to high-voltage components shall be provided with flush-mounted key-operated snaplocks and shall have provisions for padlocking.

E. INTERNAL PROTECTIVE SCREENS

1. In addition to the enclosure door, each bay or compartment thereof containing high-voltage components shall be provided with an internal protective screen, bolted closed, to guard against inadvertent entry to bays containing these components when the enclosure door is open.
2. Each bay containing a control-power transformer capable of 5 kVA or greater output shall be provided with an internal protective screen, bolted closed, to guard against inadvertent contact with the primary fuse when the enclosure door is open.
3. In such cases, the screen shall also be interlocked to ensure that the secondary load has been disconnected prior to removal of these fuses.

F. INSULATORS

1. The interrupter-switch and fuse-mounting insulators, main-bus support insulators, insulated operating shafts, and (if applicable) push rods shall be of a cycloaliphatic epoxy resin system with characteristics and restrictions as follows:
 - a. Operating experience of at least 15 years under similar conditions.

- b. Adequate leakage distance established by test per IEC publication 507, First Edition, 1975.
- c. Adequate strength for short-circuit stress established by test.
- d. Conformance with applicable ANSI standards.
- e. Homogeneity of the cycloaliphatic epoxy resin throughout each insulator to provide maximum resistance to power arcs. Ablation due to high temperatures from power arcs shall continuously expose more material of the same composition and properties so that no change in mechanical or electrical characteristics takes place because of arc-induced ablation. Furthermore, any surface damage to insulators during installation or maintenance of switchgear shall expose material of the same composition and properties so
- f. that insulators with minor surface damage need not be replaced.
- g. Isolating through-bushings for the 13.8-kV switchgear assembly shall be provided between all bays to guard against the propagation of a fault from one bay into the adjacent bay when there is more than one bay. The isolating through-bushings shall have features and capabilities as follows:
- h. The bushings shall be of a nontracking, self-scouring, nonweathering cycloaliphatic epoxy resin. Such bushings shall be the only dielectric insulating material between the energized bus conductor and the ground plane. A single semiconducting material is permissible as an interface between the energized conductors and bushings. Isolating systems that incorporate multiple insulating materials in series shall not be acceptable, thus avoiding generation of corona that can break down the weakest insulation material.
- i. ial.
- j. The bushings shall be designed for adequate BIL and certified tests shall be provided upon request.
- k. The bushings shall provide a minimum of 12-1/2 inches of leakage distance between the energized bus conductor and the ground plane.
- l. To avoid thermally induced stresses that are likely to cause interface separation and failure, the bus conductor shall not be molded or cemented into the bushing.
- m. To avoid multiple insulating materials in series that are likely to cause voltage stresses that may lead to failure, the bus conductors shall not be covered with any insulating material in an effort to achieve BIL or increased leakage distance at locations where the bus passes through the bays.
- n. The openings between the bushings and bus conductors shall be closed with a semiconducting grommet and, to avoid multiple insulating materials in series, insulating materials such as fiberglass or porcelain shall not
- o. be used for such purpose.
- p. Bushing bus conductors and main bus conductors shall be designated for direct connection and shall not require laminated or flexible bus connections.
- q. The manufacturer of the switchgear assembly shall furnish, upon request, certified tests that establish the capability of the isolating through-bushing, bus conductor, and connections to meet the short-

circuit rating of the switchgear assembly. Certified tests shall be furnished, upon request, that establish the capability of the bus connections to meet applicable temperature-rise requirements.

- r. To minimize space requirements, the overall length of the bushing shall be a maximum of 9-1/2 inches from end to end.
- s. To avoid mechanical stresses that are likely to cause interface separation and failure, the isolating through-bushing shall include a flange at the ground-plane interface that shall be a formed homogeneous section of the bushing and not a separate part of dissimilar material that is molded or cemented to the bushing.
- t. Bushings shall be secured to the ground plane by clamps that overlap the bushing flanges and press the flanges securely against the ground plane to seal the openings and restrict the propagation of ionized gases between bays.
- u. n of ionized gases between bays.
- v. For outdoor or dripproof applications, a drain channel shall be installed above the isolating through-bushings as a backup for the bay-to-bay gasketing so that any moisture entering between bays will not fall on the bushing or the bus.

G. BUS

1. High-Voltage Main Bus

- a. Bus and interconnections shall consist of copper bar with silver plated joints.
- b. The bus supports, bus, and interconnections shall withstand the stresses associated with short-circuit currents up through the maximum rating of the switchgear.
- c. Bolted connections shall be made with 1/2"—13 bronze bolts with two Belleville spring washers per bolt, one under the bolt head and one under the nut. These bolts shall be tightened to 50 foot-pounds torque.
- d. Bus to which cable will be terminated shall be equipped with grounding provisions. Grounding provisions shall also be provided on the ground bus in such bays.

2. Ground Bus

- a. A ground bus of short-circuit rating equal to that of the integrated assembly (or a ground connection, in the case of single-bay switchgear) shall be provided, maintaining electrical continuity throughout the metal-enclosed switchgear.
- b. The ground bus shall be copper.
- c. In each bay, the ground bus (or connector) shall be bolted to a nickel-plated steel bracket, which shall be welded in place.
- d. Nickel-plated steel brackets (at least one per bay) shall have a short-time current-carrying capability consistent with the short-circuit rating of the metal-enclosed switchgear.
- e. Bolted connections shall be as specified for the main bus, except that only one Belleville spring washer shall be required per bolt for attachment of ground bus to the nickel-plated steel bracket.
- f. For multi-bay metal-enclosed switchgear assemblies, two ground cable connectors accommodating No. 2 through 500 kc mil conductors shall be provided for connection of ground bus to station ground.

H. Low-Voltage Components

1. All low-voltage components, switch operators (except those integrally mounted in the switchgear stile), source-transfer controls, meters, instruments, and relays, shall be located in grounded, metal-enclosed compartments separate from high voltage to provide isolation and shall be arranged to allow complete accessibility for operation without exposure to high voltage.
2. Space heaters, where used, shall have a grounded, perforated, galvanized steel guard.
3. To provide isolation from high voltage, low-voltage wiring, except for short lengths such as at terminal blocks or at secondaries of sensing devices, shall be in grounded conduit, cable trays, or raceways.

I. Cable-Termination Space

1. To facilitate cable pulling and installation of cable terminators, provisions shall be made for:
 - a. Full front access for positioning and removal of cable pulling sheaves.
 - b. Free access without interference from nonremovable structural members or from mechanical linkages between the interrupter-switch blades and operating mechanism.
 - c. Switchgear bay shall have provisions for incoming cable through the roof of the switchgear bay and a removable plate on the side of the switchgear bay for the exiting cable.

J. Reverse Power Relaying

1. 3 VT's connected phase to ground shall be provided by the manufacturer in bay 3 which will be for control power, reverse power relay and for the SEL 735 meter
2. Provision for 3 VT's connected phase to ground shall be provided by the manufacturer in bay 2 for future reverse power relay and SEL 735 meter
3. 3 CT's with a 600:5 ratio shall be provided in bay 3 and wired to a SEL 735 meter and Basler 59-1 relay with cat # BE A6F-A1J-C2N0F with test switches.
4. Provision for 3 CT's with a 600:5 ratio shall be provided in bay 2 for future SEL 735 meter and reverse power relay.
5. The meters and relays shall be mounted on the door of each feeder bay.

K. Control Power

1. Control power shall be provided from the internal VT's.

L. IR Windows

1. 2 sets of IR windows shall be provided in each bay.

M. Lights

1. A light and light switch shall be provided in each bay.

N. Auxiliary contacts

1. Auxiliary contacts shall be provided for each motor operator.

2.5 FINISH AND FEATURES

A. Outdoor Switchgear

1. Outdoor Finish

- a. The enclosure finish shall conform to or exceed the applicable requirements of ANSI C57.12.28.
- b. During fabrication, the areas of structural parts which may later become inaccessible, such as folded edges and overlapping members, shall be given an iron-oxide zinc-chromate anticorrosion primer to ensure that all surfaces are protected.
- c. Full coverage at joints and blind areas shall be achieved by processing enclosures independently of components such as doors and roofs before assembly into the unitized structures.
- d. To remove oils and dirt, to form a chemically and anodically neutral conversion coating to improve the finish-to-metal bond, and to retard underfilm propagation of corrosion, all surfaces shall undergo a thorough pretreatment process comprised of a fully automated system of cleaning, rinsing, phosphatizing, sealing, drying, and cooling before any protective coatings are applied. By utilizing an automated pretreatment process, the enclosure will receive a highly consistent thorough treatment, eliminating flu
- e. ctuations in reaction time, reaction temperature, and chemical concentrations.
- f. After pretreatment, protective coatings shall be applied that shall help resist corrosion and protect the steel enclosure. To establish the capability to resist corrosion and protect the enclosure, representative test specimens coated by the enclosure manufacturer's finishing system shall satisfactorily pass the following tests:
 - 1) 4000 hours of exposure to salt-spray testing per ASTM B 117 with:
 - a) Underfilm corrosion not to extend more than 1/32" from the scribe as evaluated per ASTM D 1654, Procedure A, Method 2 (scraping); and
 - b) Loss of adhesion from bare metal not to extend more than 1/8" from the scribe.
 - 2) 1000 hours of humidity testing per ASTM D 4585 with no blistering as evaluated per ASTM D 714.
 - 3) 500 hours of ultraviolet accelerated weathering testing per ASTM G 53 using lamp UVB-313 with no chalking as evaluated per ASTM D 659, and no more than a 10% reduction of paint gloss as evaluated per ASTM D 523.
 - 4) Crosshatch adhesion testing per ASTM D 3359 Method B with no loss of paint.
 - 5) 160-inch-pound impact adhesion testing per ASTM D 2794 with no paint chipping or cracking.
 - 6) Oil resistance testing consisting of a 72-hour immersion bath in mineral oil with no shift in color, no streaking, no blistering, and no loss of hardness.
 - 7) 3000 cycles of abrasion testing per ASTM 4060 with no penetration to the substrate.

- 8) Certified test abstracts substantiating the above capabilities shall be furnished upon request.
- g. A heavy coat of insulating "no-drip" compound shall be applied to the inside surface of the roof structure to prevent condensation of moisture thereon.
- h. After the enclosures are completely assembled and the components (switches, fuses, bus, etc.) are installed, the finish shall be inspected for scuffs and scratches. Blemishes shall be touched up to restore the protective integrity of the finish.
- i. Touch-up materials—with complete instructions—shall be included with each shipment of metal-enclosed switchgear for touch-up in the field.
- j. The finish shall be light gray, satisfying the requirements of ANSI Standard Z55.1 for No. 61 or No. 70.

B. Outdoor Features

- 1. Enclosure Ventilation
 - a. Ventilation openings shall be provided at the top and bottom on the front and rear of each bay. Ventilation openings on the front of arc-resistant switchgear shall be provided at the top only.
 - b. Vents shall be rain-resistant and corrosion-resistant.
 - c. Each vent shall have an inside screen and baffle to exclude insects and to protect against insertion of foreign objects.
 - d. In consideration of exceptionally high concentrations of airborne dust, externally accessible glass-fiber filters shall be provided.
- 2. Lifting eyes shall be removable. Sockets for lifting eyes shall be blind-tapped.
- 3. Gasketing and Sealing
 - a. Door openings and openings for hinged bolted panels (and bolted panels providing access to low-voltage components) shall have resilient compression gasketing to prevent water from entering the enclosure.
 - b. Gasket seals shall be provided at the top and side edges of adjoining bays to prevent water entry between the double walls.
 - c. The top and both sides of bus openings between bays shall be covered with channel gaskets as an additional protection against entrance of water or external labyrinthine metal rainshields shall be provided over enclosure roof flanges between adjacent bays.
 - d. Roofs shall be weather-sealed in place with a suitable sealant.
- 4. Space Heaters
 - a. Space heaters with sheaths of high-temperature chrome steel shall be provided to maintain air circulation inside the enclosure.
 - b. There shall be a space heater in each bay.
 - c. Space heaters shall be wired.
- 5. Lights and light switches shall be provided in each bay.

2.6 BASIC COMPONENTS

A. Interrupter Switches

- 1. Interrupter switches shall have a one-time or two-time duty-cycle fault-closing rating equal to or exceeding the short-circuit rating of the switchgear. These ratings define the ability to close the interrupter switch either alone

- (unfused) or in combination with the appropriate fuse, once or twice (as applicable) against a three-phase fault with asymmetrical current in at least one phase equal to the rated value, with the switch remaining operable and able to carry and interrupt rated current. Tests substantiating these ratings shall be performed at maximum voltage. Certified test abstracts establishing such ratings shall be furnished upon request.
2. Interrupter switches intended for manual operation shall be operated by means of an externally operable, nonremovable handle. The handle shall have provisions for padlocking in both the open and a closed positions. Interrupter switches intended for power operation shall be operated by means of a switch operator expressly designed to be compatible with the interrupter switch.
 3. Interrupter switches shall utilize a quick-make quick-break mechanism installed by the switch manufacturer, which shall swiftly and positively open and close the interrupter switch independent of the switch-handle or switch operator operating speed.
 - a. For manually operated interrupter switches, and for interrupter switches operated by direct motor drive switch operators, the quick-make quick-break mechanism shall be integrally mounted to the switch frame.
 - b. For interrupter switches operated by stored-energy switch operators, the quick-make quick-break mechanism shall be an integral part of the switch operator.
 4. Interrupter switches shall be completely assembled and adjusted by the switch manufacturer on a single rigid mounting frame. The frame shall be of welded steel construction such that the frame intercepts the leakage path which parallels the open gap of the interrupter switch, to positively isolate the load circuit when the interrupter switch is in the open position.
 5. Interrupter switches shall be provided with a single blade per phase for circuit closing including fault closing, continuous current carrying, and circuit interrupting. Spring-loaded auxiliary blades shall not be permitted.
 6. Circuit interruption shall be accomplished by use of an interrupter which is positively and inherently sequenced with the blade position. Circuit interruption shall take place completely within the interrupter, with no external arc or flame. Any exhaust shall be vented in a controlled manner through a labyrinthine muffler or a deionizing vent.
 7. Interrupter switches shall have a readily visible open gap when in the open position to allow positive verification of switch position.
 8. Terminals on interrupter switches to which cable will be terminated shall be equipped with grounding provisions. Grounding provisions shall also be provided on the ground bus in such bays.
 9. The bus tie switch shall be mounted to the roof of the switchgear bay and be in line with the bus.

B. Fuses

1. Solid-Material SM-40 Power Fuses without substitution
 - a. Solid-material power fuses shall be of the solid-material type and shall utilize refill-unit-and-holder or fuse-unit-and-end-fitting construction. The refill unit or fuse unit shall be readily replaceable.
 - b. For switchgear rated up through 600 MVA at 13.8 kv, mountings for solid-material power fuses shall be disconnect style. Non-disconnect

style mountings for power fuses shall be used only where higher ratings are required.

- c. Fusible elements shall be nonaging and nondamageable so that it is unnecessary to replace unblown companion fuses following a fuse operation.
- d. Fusible elements for refill units or fuse units, rated 10 amperes or larger, shall be helically coiled to avoid mechanical damage due to stresses from current surges.
- e. Fusible elements that carry continuous current shall be supported in air to help prevent damage from current surges.
- f. Solid-material power fuses shall have melting time-current characteristics that are permanently accurate with a maximum total tolerance of 10% in terms of current. Time-current characteristics shall be available which permit coordination with protective relays, automatic circuit reclosers, and other fuses.
- g. Solid-material power fuses shall be capable of detecting and interrupting all faults whether large, medium, or small (down to minimum melting current), under all realistic conditions of circuitry, with line-to-line or line-to-ground voltage across the power fuses, and shall be capable of handling the full range of transient recovery voltage severity associated with these faults.
- i. All arcing accompanying power fuse operation shall be contained within the fuse, and any arc products and gases evolved during fuse operation shall be vented through exhaust control devices that shall effectively control fuse exhaust.
- j. Solid-material power fuses shall be equipped with a blown-fuse indicator that shall provide visible evidence of fuse operation while installed in the fuse mounting.
- k. Solid-material power fuses in feeder bays shall be equipped with grounding provisions on the load side of each fuse and on the enclosure ground bus.

C. Switch Operators

- 1. The following requirements apply to switch operators that incorporate an integral quick-make quick-break mechanism for solenoid trip-open and solenoid trip-closed operation with motor recharge—for use with interrupter switches rated 13.8 kV nominal, 600 amperes load interrupting or less.
 - a. Switch operators shall be of the stored-energy type. They shall be equipped with an integral quick-make quick-break mechanism installed by the switch operator manufacturer, which shall store sufficient mechanical energy to
 - b. either open or close the interrupter switch. The quick-make quick-break mechanism shall swiftly and positively open and close the associated interrupter switch independent of the speed of the charging motor or manual handle.
 - c. Switch operators shall be equipped with a tripping solenoid to release the stored energy to open or close the associated interrupter switch in response to a control signal. Total operating time for opening or closing shall not exceed 4 cycles from the time the solenoid is energized.

- d. Switch operators shall be equipped with a charging motor that shall charge the quick-make quick-break mechanism within 12\seconds after each switch operation.
- e. Switch operators shall be equipped with a torque limiter to absorb deceleration forces when travel limits are reached during charging to allow the motor to positively and completely charge the quick-make quick-break mechanism without transmitting excessive torque to the mechanism.
- f. Pushbuttons shall be provided to permit local electrical trip-open and trip-closed operation. Local electrical operation shall be prevented when the source-transfer control is in the automatic mode.
- g. Switch operators shall be provided with a manual charging access port and a removable manual-charging handle to allow manual charging of the quick-make quick-break mechanism in the absence of control power. While the manual charging access port is open, the motor-charging circuit shall be disconnected to prevent
- h. inadvertent electrical charging of the quick-make quick-break mechanism.
- i. Switch operators shall be equipped to permit local mechanical trip-open and trip-closed operation in the event control power is lost.
- j. Switch operators shall be located within a grounded, metal-enclosed low-voltage compartment in the switchgear stile, and shall be mounted on a drawout carriage. The metal-enclosed compartment shall provide isolation from high voltage to help protect operating personnel. The drawout carriage shall permit decoupling of the switch operator from the associated interrupter switch for testing and exercising of the switch operator without opening or closing the interrupter switch and without exposure to high voltage.
- k. When the switch operator is decoupled, the associated interrupter switch shall be locked open or closed, depending upon switch position at the time of decoupling. It shall not be possible to recouple the switch operator to the interrupter switch unless the switch operator is in the same position (open or closed) as the interrupter switch.
- l. Switch operators shall be equipped with targets to show whether the quick-make quick-break mechanism is charged or discharged; whether the switch operator is in the switch-open or switch-closed position; whether the associated interrupter switch is in the open or closed position; and whether the switch operator is in the coupled or decoupled position.
- m. Switch operators shall be equipped with an operation counter.
- n. Switch operators shall be provided with a hinged padlockable steel cover or door to protect the switch operators and to guard against tampering. The cover or door shall be equipped with windows (unless Category A enclosures are required) to allow observation of the switch operator targets. Gasketing shall be installed between the cover or door and the mounting surfaces.
- o. Switch operators shall be equipped with an extra 4-PDT auxiliary switch coupled to the switch operator.

- p. A receptacle shall be provided for attachment of a remote-control station to allow electrical trip-open and trip-closed operation from an adjacent area.
- D. Single-Phasing Protection on Ungrounded and Grounded Systems with a Specialty Current Detection Relay—Power-Operated Feeders
- 1. Specialty relays shall be provided for power-operated feeders to protect three- phase loads from Single Phasing conditions. The specialty relay shall trip the associated switch operator after a downstream fault has been cleared by the feeder fuse(s) or the source-side protective device.
 - 2. Specialty relays shall employ proven solid-state electronic components and shall continuously monitor the current in each phase of the feeder circuit. Specialty relays shall be capable of distinguishing between transformer inrush current and fault current and produce a trip signal only on fault currents.
 - 3. Specialty relays shall:
 - a. Use closed-gap current sensors to sense the current in each phase of the feeder circuit.
 - b. Include a TRIP indicator that displays a red target when the relay has operated. A pushbutton shall be provided to reset the TRIP indicator.
 - c. Provide for field adjustment of the trip-level detector setting over the range 400 to 2400 amperes. This setting shall determine the level of phase current above which the relay is to respond.
 - d. Include a PICKUP indicator lamp that illuminates when an overcurrent that exceeds the trip-level setting has been detected. The lamp shall extinguish after the relay has operated and shall have a Push to Test feature.
 - e. Include a field-adjustable delay timer for selecting the duration between detection of an overcurrent and initiation of a tripping operation as a means to confirm whether the overcurrent is momentary or permanent. The timer range shall be from 1 to 35 seconds.
 - f. Use, on detection of an overcurrent, a two-millisecond time delay before starting the field-adjustable 1- to 35-second tripping circuit timer to eliminate response to transient disturbances.
 - g. Include a field-selectable Inrush Restraint feature that shall inhibit relay response to overcurrents occurring during initial energization or during reclosing of a source-side protective device. The Inrush Restraint feature shall delay, for one second, the starting of the two-millisecond time relay.
 - h. Include an elapsed-time indicator lamp that illuminates when the delay timer times out. The lamp shall extinguish after the relay has operated and shall have a Push to Test feature.
 - i. Reset if normal load current of 3.5 amperes or greater returns on all three phases before the delay timer times out.
 - j. Include test jacks to simulate proper functioning of the three-phase over- current relay in response to transformer inrush currents and fault currents and to permit verification of the pickup and trip levels as well as

the trip- current timer setting. (These test jacks shall also permit verification of the proper functioning of the current sensors.)

k. Use a blocking circuit to prevent tripping of the switch operator while the overcurrent exceeds 600 amperes.

l. Mount in a grounded, metal-enclosed low-voltage compartment in the switch- gear stile. (The metal-enclosed compartment shall provide complete isolation from high voltage.)

5. The surge-withstand capability of all overcurrent relays shall be verified by subjecting each device to both the ANSI/IEEE Surge Withstand Capability Test (ANSI Standard C37.90.1) and to :

a. ANSI Standard C62.41 Category B Power Line Surge

6. Specialty relays shall use printed-circuit-board construction.

To ensure the high quality and reliability of the electronic components, all specialty relays shall be subjected to a dielectric test, a functional check, and a 48-hour screening test followed by a second functional test. For the screening test, the specialty relay shall be energized at rated control voltage while subjected to 48 hours of temperature cycling repeatedly between -40°C (-40°F) and 65°C (149°F).

2.7 LABELING

- A. Comply with requirements for labels and signs specified in Section 26 05 53 "Identification for Electrical Systems."

B. Warning Signs

1. All external doors and hinged bolted panels providing access to high voltage shall be provided with "Caution—High Voltage—Keep Out" signs.
2. All internal protective screens providing access to high voltage shall be provided with "Danger—High Voltage—Keep Out—Qualified Persons Only" signs.
3. All internal protective screens providing access to interrupter switches shall be provided with warning signs indicating that "Switch Blades May Be Energized in Any Position."
4. All internal protective screens providing access to fuses shall be provided with warning signs indicating that "Fuses May Be Energized in Any Position."

C. Rating Nameplates

1. The integrated switchgear assembly shall be provided with an external nameplate indicating the manufacturer's drawing number and the following: voltage ratings (kV, nominal; kV, maximum; kV, BIL); main bus continuous rating (amperes); short-circuit ratings (amperes, RMS symmetrical and MVA three-phase symmetrical at rated nominal voltage); and the momentary and fault-closing ratings (amperes, RMS asymmetrical). When the assembly is UL listed, the external nameplate shall include the UL classification marking comprised of "UL" in a circle; the word "Listed"; the assigned control number; and the product identity.
2. Each individual bay shall bear a nameplate indicating the ratings of the interrupter switch (amperes, continuous and interrupting); the maximum

rating of the fuse in amperes; and the catalog number of the fuse units, refill units, interrupting module, or control module. When the individual bay is to be UL listed, this nameplate shall include the UL classification markings comprised of "UL" in a circle; the word "Listed"; the assigned control number; and the product identity. In addition, the enclosure category shall be specified.

2.8 SOURCE QUALITY CONTROL

- A. Perform production tests on each circuit breaker housing for this Project, complying with IEEE C37.20.3:
 - 1. Perform mechanical operation tests to ensure proper functioning of shutters, operating mechanism, mechanical interlocks, and interchangeability of removable elements that are designed to be interchangeable.
 - 2. Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence.
 - 3. Perform the control wiring dielectric test at 1500 V for one minute.
- B. Perform production tests, on each circuit breaker supplied for this Project, complying with IEEE C37.20.4.
 - 1. Perform mechanical operation tests to ensure proper functioning of the switch.
 - 2. Verify the contact gap. Perform terminal-to-terminal resistance test.
 - 3. Verify that control wiring is correct by verifying continuity. Perform electrical operation of relays and devices to ensure they function properly and in the intended sequence.
 - 4. Perform the control wiring dielectric test at 1500 V for one minute.
- C. Owner will witness required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Upon delivery of switchgear and prior to unloading, inspect equipment for damage.
 - 1. Examine tie rods and chains to verify they are undamaged and tight and that blocking and bracing are tight.
 - 2. Verify that there is no evidence of load shifting in transit and that readings from transportation shock recorders, if equipped, are within manufacturer's recommendations.
 - 3. Examine switchgear for external damage, including dents or scratches in doors and sill, and termination provisions.

4. Compare switchgear and accessories received with the bill of materials to verify that the shipment is complete. Verify that switchgear and accessories conform to the manufacturer's quotation and shop drawings. If the shipment is not complete or does not comply with project requirements, notify the manufacturer in writing immediately.
5. Unload switchgear, observing packing label warnings and handling instructions.
6. Open compartment doors and inspect components for damage or displaced parts, loose or broken connections, cracked or chipped insulators, bent mounting flanges, dirt or foreign material, and water or moisture.

B. Handling:

1. Handle switchgear according to manufacturer's recommendations; avoid damage to the enclosure, termination compartments, base, frame, tank, and internal components. Do not subject switchgear to impact, jolting, jarring, or rough handling.
2. Protect switchgear compartments against the entrance of dust, rain, and snow.
3. Transport switchgear upright to avoid internal stresses on equipment mounting assemblies. Do not tilt or tip switchgear.
4. Use spreaders or a lifting beam to obtain a vertical lift and to protect switchgear from straps bearing against the enclosure. Lifting cable pull angles may not be greater than 15 degrees from vertical.
5. Do not damage structure when handling switchgear.

C. Storage:

1. Store switchgear in a location that is clean and protected from weather. Protect switchgear from dirt, water, contamination, and physical damage. Do not store switchgear in the presence of corrosive or explosive gases.
2. Store switchgear with compartment doors closed.
3. Regularly inspect switchgear while in storage and maintain documentation of storage conditions, noting any discrepancies or adverse conditions.

D. Examine roughing-in of conduits and grounding systems to verify the following:

1. Wiring entries comply with layout requirements.
2. Entries are within conduit-entry tolerances specified by manufacturer, and no feeders will have to cross section barriers to reach load or line lugs.

E. Pre-Installation Checks:

1. Verify removal of any shipping bracing after placement.

F. Verify that ground connections are in place and that requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be [5 ohms] <Insert value> at switchgear location.

G. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SWITCHGEAR INSTALLATION

A. Equipment Mounting:

1. Install switchgear on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 03 30 00 "Cast-in-Place Concrete."
2. Comply with requirements for vibration isolation and seismic control devices specified in Section 26 05 48 "Seismic Controls for Electrical Systems."
3. Comply with requirements for vibration isolation devices specified in Section 26 05 29 "Hangers and Supports for Electrical Systems."

B. Switchgear shall be installed level and plumb. Switchgear shall tilt less than 1.5 degrees while energized.

C. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

D. Comply with NECA 1.

E. Comply with NECA 430.

3.3 CONNECTIONS

A. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Grounding Connections at Interior Locations:

1. Install bare copper cable not smaller than No. 4/0 AWG for grounding to grounding electrodes.
2. Bond surge arrester and neutrals directly to the switchgear enclosure and then to the grounding electrode system with bare copper conductors.
3. Keep leads as short as practicable with no kinks or sharp bends.
4. Make joints in grounding conductors and loops by exothermic weld or compression connector.

C. Grounding Connections at Exterior Locations:

1. Install tinned bare copper cable not smaller than No. 4/0 AWG, for counterpoise buried not less than 30 inches (765 mm) below grade interconnecting the grounding electrodes.
2. Bond surge arrester and neutrals directly to the switchgear enclosure and then to the grounding electrode system with bare copper conductors, sized as shown.
3. Keep lead lengths as short as practicable with no kinks or sharp bends.
4. Fence and equipment connections shall not be smaller than No. 4 AWG.
5. Ground fence at each gate post and corner post and at intervals not exceeding 10 ft. (3050 mm).

6. Bond each gate section to the fence post using 1/8 by 1 inch (3 by 25 mm) tinned flexible braided copper strap and clamps.
 7. Make joints in grounding conductors and loops by exothermic weld or compression connector.
- D. Terminate all grounding and bonding conductors on a common equipment grounding terminal on the switchgear enclosure. Install supplemental terminal bars, lugs, and bonding jumpers as required to accommodate the number of conductors for termination.
- E. Complete switchgear grounding and lightning arrester connections prior to making any other electrical connections.
- F. Terminate medium-voltage cables according to Section 26 05 13 "Medium-Voltage Cables."

3.4 SIGNS AND LABELS

- A. Comply with the installation requirements for labels and signs specified in Section 26 05 53 "Identification for Electrical Systems."
- B. Install warning signs as required to comply with OSHA in 29 CFR 1910.269.

3.5 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. General Field Testing Requirements:
1. Comply with the provisions of NFPA 70B, "Testing and Test Methods."
 2. After installing switchgear and after electrical circuitry has been energized, test for compliance with requirements.
 3. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
- F. Medium-Voltage Switchgear Assembly Field Tests:
1. Visual and Mechanical Inspection:

- a. Verify that fuse and circuit breaker sizes and types correspond to Drawings and coordination study.
- b. Verify that current and voltage transformer ratios correspond to Drawings.
- c. Inspect bolted electrical connections using calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
- d. Confirm correct operation and sequencing of electrical and mechanical interlock systems.
 - 1) Attempt closure on locked-open devices. Attempt to open locked-closed devices.
 - 2) Make key exchange with devices operated in off-normal positions.
- e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
- f. Inspect insulators for evidence of physical damage or contaminated surfaces.
- g. Verify correct barrier and shutter installation and operation.
- h. Exercise active components.
- i. Inspect mechanical indicating devices for correct operation.
- j. Verify that filters are in place and vents are clear.
- k. Perform visual and mechanical inspection of instrument transformers according to Article "Instrument Transformer Field Tests."
- 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 and grounding contacts and interlocks.

2. Electrical Tests:

- a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted 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.
- b. Perform dc voltage insulation-resistance tests on each bus section, phase to phase and phase to ground, for one minute. If the temperature of the bus is other than plus or minus 20 deg C, adjust the resulting resistance as provided in NETA ATS, Table 100
- c. .11.

- 1) Insulation-resistance values of bus insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
 - 2) Do not proceed to the dielectric withstand voltage tests until insulation-resistance levels are raised above minimum values.
- d. Perform a dielectric withstand voltage test on each bus section, each phase to ground with phases not under test grounded, according to manufacturer's published data. If manufacturer has no recommendation for this test, it shall be conducted according to NETA ATS, Table 100.2. Apply the test voltage for one minute.
- 1) If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the test specimen is considered to have passed the test.
 - 2) ended the test.
- e. Perform insulation-resistance tests on control wiring with respect to ground. Applied potential shall be 500 volts dc for 300-volt rated cable and 1000 V dc for 600-V rated cable. Test duration shall be one minute. For units with solid-state components or control devices that cannot tolerate the applied voltage, follow the manufacturer's recommendation.
- 1) Minimum insulation-resistance values of control wiring shall not be less than two megohms.
- f. Control Power Transformers:
- 1) Perform insulation-resistance tests. Perform measurements from winding to winding and each winding to ground. Insulation-resistance values of winding insulation shall be according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.1.
 - 2) Perform secondary wiring integrity test. Disconnect transformer at secondary terminals and
 - 3) connect secondary wiring to a rated secondary voltage source. Verify correct potential at all devices.
 - 4) Verify correct secondary voltage by energizing the primary winding with system voltage. Measure secondary voltage with the secondary wiring disconnected.
 - 5) Verify correct function of control transfer relays located in the switchgear with multiple control power sources.
- g. Voltage Transformers:

- 1) Perform secondary wiring integrity test. Verify correct potential at all devices.
 - 2) Verify secondary voltages by energizing the primary winding with system voltage.
- h. Perform current-injection tests on the entire current circuit in each section of switchgear.
- 1) Perform current tests by secondary injection with magnitudes such that a minimum current of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
 - 2) Perform current tests by primary injection with magnitudes such that a minimum of 1.0 A flows in the secondary circuit. Verify correct magnitude of current at each device in the circuit.
- i. Perform system function tests according to "System Function Tests" Article.
- j. Verify operation of space heaters.
- k. Perform phasing checks on double-ended or dual-source switchgear to ensure correct bus phasing from each source.

G. Instrument Transformer Field Tests:

1. Visual and Mechanical Inspection:

- a. Verify that equipment nameplate data complies with Contract Documents.
- b. Inspect physical and mechanical condition.
- c. Verify correct connection of transformers with system requirements.
- d. Verify that adequate clearances exist between primary and secondary circuit wiring.
- e. Verify the unit is clean.
- f. Inspect bolted electrical connections using calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
- g. Verify that required grounding and shorting connections provide contact.
- h. Verify correct operation of transformer withdrawal mechanism and grounding operation.
- i. Verify correct primary and secondary fuse sizes for voltage transformers.
- j. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

2. Electrical Tests of Current Transformers:

- a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted 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.

- b. Perform insulation-resistance test of each current transformer and its secondary wiring with respect to ground at 1000 V dc for one minute. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's written recommendations.
- c. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.5.
- d. Perform a polarity test of each current transformer according to IEEE C57.13.1. Polarity results shall agree with transformer markings.
- e. Perform a ratio-verification test using the voltage or current method according to IEEE C57.13.1. Ratio errors shall be according to IEEE C57.13.
- f. Perform an excitation test on transformers used for relaying applications according to IEEE C57.13.1. Excitation results shall match the curve supplied by the manufacturer or be according to IEEE C57.13.1.
- g. Measure current circuit burdens at transformer terminals according to IEEE C57.13.1. Measured burdens shall be compared with and shall match instrument transformer ratings.
- h. Perform insulation-resistance tests on the primary winding with the secondary grounded. Test voltages shall be according to Table 100.5.
- i. Perform dielectric withstand tests on the primary winding with the secondary grounded. Test voltages shall be according to Table 100.9.
- j. Perform power-factor or dissipation-factor tests according to test equipment manufacturer's published data.
- k. Verify that current transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3. That grounding point should be located as specified by the engineer in the project drawings.

3. Electrical Tests of Voltage Transformers:

- a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted 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.
- b. Perform insulation-resistance tests winding-to-winding and each winding to ground. Test voltages shall be applied for one minute according to Table 100.5. For units with solid-state components that cannot tolerate the applied voltage, follow manufacturer's recommendations.
- c. Investigate and correct values of insulation resistance less than manufacturer's recommendations or NETA ATS, Table 100.5.
- d. Perform a polarity test on each transformer to verify the polarity marks or H1- X1 relationship as applicable. Polarity results shall agree with transformer markings.
- e. Perform a turns-ratio test on all tap positions. Ratio errors shall be according to IEEE C57.13.

- f. Measure voltage circuit burdens at transformer terminals. Measured burdens shall be compared with and shall match instrument transformer ratings.
- g. Perform a dielectric withstand test on the primary windings with the secondary windings connected to ground. The dielectric voltage shall be according to Table 100.9. The test voltage shall be applied for one minute. If no evidence of distress or insulation failure is observed by the end of the total time of voltage application during the dielectric withstand test, the primary windings are considered to have passed the test.
- h. Perform power-factor or dissipation-factor tests according to test equipment manufacturer's published data. Power-factor or dissipation-factor values shall be according to manufacturer's published data. In the absence of manufacturer's published data, use test equipment manufacturer's published data.
- i. Verify that voltage transformer secondary circuits are grounded and have only one grounding point according to IEEE C57.13.3. Test results shall indicate that the circuits are grounded at only one point.

H. Ground Resistance Test:

1. Visual and Mechanical Inspection:

- a. Verify ground system complies with the Contract Documents and NFPA 70 Article 250, "Grounding and Bonding."
- b. Inspect physical and mechanical condition. Grounding system electrical and mechanical connections shall be free of corrosion.
- c. Inspect bolted electrical connections using a calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
- d. Inspect anchorage.

2. Electrical Tests:

- a. Perform fall-of-potential or alternative test according to IEEE 81 on the main grounding electrode or system. The resistance between the main grounding electrode and ground shall be no more than [5 ohms] [maximum ground resistance value specified in "Examination" Article].
- b. Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and derived neutral points. Investigate point-to-point resistance values that exceed 0.5 ohms. Compare equipment nameplate data with Contract Documents.
- c. Inspect physical and mechanical condition.
- d. Inspect bolted electrical connections for high resistance using a low-resistance ohmmeter to 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.

I. Metering Devices Field Tests:

1. Visual and Mechanical Inspection:

- a. Inspect physical and mechanical condition.
- b. Inspect bolted electrical connections using calibrated torque-wrench method according to manufacturer's published data or NETA ATS, Table 100.12. Bolt-torque levels shall be according to manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS, Table 100.12.
- c. Inspect cover gasket, cover glass, condition of spiral spring, disk clearance, contacts, and case shorting contacts, as applicable.
- d. Verify the unit is clean.
- e. Verify freedom of movement, end play, and alignment of rotating disk(s).

2. Electrical Tests:

- a. Inspect bolted electrical connections using a low resistance ohmmeter to compare bolted 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.
- b. Verify accuracy of meters at all cardinal points. Meter accuracy shall be according to manufacturer's published data.
- c. Calibrate meters according to manufacturer's published data. Calibration results shall be within manufacturer's published tolerances.
- d. Verify all instrument multipliers. Instrument multipliers shall be according to system design specifications.
- e. Verify that current transformer and voltage transformer secondary circuits are intact. Test results shall confirm the integrity of the secondary circuits of current and voltage transformers.

J. Medium-Voltage Surge Arrester Field Tests:

1. Visual and Mechanical Inspection:

- a. Verify that equipment nameplate data complies with Contract Documents.
- b. Inspect physical and mechanical condition.
- c. Inspect anchorage, alignment, grounding, and clearances.
- d. Verify the arresters are clean.
- e. Verify that the ground lead on each device is individually attached to a ground bus or ground electrode.
- f. Verify that the stroke counter is correctly mounted and electrically connected if applicable. Record the stroke counter reading.

2. Electrical Test:

- a. Perform an insulation-resistance test on each arrester, phase terminal to ground. Apply voltage according to manufacturer's published data. In the absence of manufacturer's published data, comply with NETA ATS, Table 100.1. Replace units that fail to meet recommended minimum insulation resistance listed in the table.
- b. Perform a watts-loss test. Evaluate watts-loss values by comparison with similar units and test equipment manufacturer's published data.
- c. Test grounding connections. Resistance between the arrester ground terminal and the ground system shall be less than 0.5 ohm.

K. Microprocessor-Based Protective Relay Field Tests:

1. Visual and Mechanical Inspection:

- a. Record model number, style number, serial number, firmware revision, software revision, and rated control voltage.
- b. Verify operation of light-emitting diodes, display, and targets.
- c. Record passwords for each access level.
- d. Clean the front panel and remove foreign material from the case.
- e. Check tightness of connections.
- f. Verify that the frame is grounded according to manufacturer's instructions.
- g. Set the relay according to results in Section 26 05 73 "Overcurrent Protective device coordination and arc flash analysis."
- h. Download settings from the relay. Print a copy of the settings for the report and compare the settings to those specified in the coordination study.

2. Electrical Tests:

- a. Perform insulation-resistance tests from each circuit to the grounded frame according to manufacturer's published data.
- b. Apply voltage or current to analog inputs, and verify correct registration of the relay meter functions.
- c. Functional Operation: Check functional operation of each element used in the protection scheme as follows:

1) Timing Relay:

- a) Determine time delay.
- b) Verify operation of instantaneous contacts.

2) Volts/Hertz Relay:

- a) Determine pickup frequency at rated voltage.
- b) Determine pickup frequency at a second voltage level.
- c) Determine time delay.

- 3) Sync Check Relay:
 - a) Determine closing zone at rated voltage.
 - b) Determine maximum voltage differential that permits closing at zero degrees.
 - c) Determine live line, live bus, dead line, and dead bus set points.
 - d) Determine time delay.
 - e) Verify dead bus/live line, dead line/live bus, and dead bus/dead line control functions.
- 4) Undervoltage Relay:
 - a) Determine dropout voltage.
 - b) Determine time delay.
 - c) Determine time delay at a second point on the timing curve for inverse time relays.
- 5) Directional Power Relay:
 - a) Determine minimum pickup at maximum torque angle.
 - b) Determine closing zone.
 - c) Determine maximum torque angle.
 - d) Determine time delay.
 - e) Verify time delay at a second point on the timing curve for inverse time relays.
 - f) Plot the operating characteristic.
- 6) Current Balance Relay:
 - a) Determine pickup of each unit.
 - b) Determine percent slope.
 - c) Determine time delay.
- 7) Negative Sequence Current Relay:
 - a) Determine negative sequence alarm level.
 - b) Determine negative sequence minimum trip level.
 - c) Determine maximum time delay.
 - d) Verify two points on the I-two-squared-t curve.
- 8) Phase Sequence or Phase Balance Voltage Relay:
 - a) Determine positive sequence voltage to close the NO contact.
 - b) Determine positive sequence voltage to open the NC contact (undervoltage trip).
 - c) Verify negative sequence trip.
 - d) Determine time delay to close the NO contact with sudden application of 120 percent of pickup.

- e) Determine time delay to close the NC contact upon removal of voltage when previously set to rated system voltage.
- 9) Instantaneous Overcurrent Relay:
 - a) Determine pickup.
 - b) Determine dropout.
 - c) Determine time delay.
- 10) Time Overcurrent:
 - a) Determine minimum pickup.
 - b) Determine time delay at two points on the time current curve.
- 11) Ground Detector Relay:
 - a) Determine maximum impedance to ground causing relay pickup.
- 12) Directional Overcurrent Relay:
 - a) Determine directional unit minimum pickup at maximum torque angle.
 - b) Determine closing zone.
 - c) Determine maximum torque angle.
 - d) Plot operating characteristics.
 - e) Determine overcurrent unit pickup.
 - f) Determine overcurrent unit time delay at two points on the time current curve.
- d. Control Verification:
 - 1) Functional Tests:
 - a) Check operation of all active digital inputs.
 - b) Check output contacts or silicone-controlled rectifiers (SCRs), preferably by operating the controlled device, such as circuit breaker, auxiliary relay, or alarm.
 - c) Check internal logic functions used in protection scheme.
 - d) Upon completion of testing, reset min/max recorders, communications statistics, fault counters, sequence-of-events recorder, and event records.
 - 2) In-Service Monitoring: After the equipment is initially energized, measure magnitude and phase angle of inputs and verify expected values.
- L. Switchgear will be considered defective if it does not pass tests and inspections.

- M. Remove and replace defective units and retest.
- N. Prepare test and inspection reports. Record as-left set points of adjustable devices.

3.6 SYSTEM FUNCTION TESTS

- A. System function tests shall prove the correct interaction of sensing, processing, and action devices. Perform system function tests after field quality control tests have been completed and all components have passed specified tests.
 - 1. Develop test parameters and perform tests for the purpose of evaluating performance of integral components and their functioning as a complete unit within design requirements and manufacturer's published data.
 - 2. Verify the correct operation of interlock safety devices for fail-safe functions in addition to design function.
 - 3. Verify the correct operation of sensing devices, alarms, and indicating devices.

3.7 FOLLOW-UP SERVICE

- A. Voltage Monitoring and Adjusting: After Substantial Completion, but not more than six months after Final Acceptance, if requested by Owner, perform the following voltage monitoring:
 - 1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at the outgoing section of each switchgear. Use voltmeters with calibration traceable to NIST standards and with a chart speed of not less than 1 inch (25 mm) per hour. Voltage unbalance greater than 1 percent between phases, or deviation of phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.
 - 2. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
 - a. Adjust switchgear taps.
 - b. Prepare written request for voltage adjustment by electric utility.
 - 3. Retests: Repeat monitoring, after corrective action has been performed, until specified results are obtained.
 - 4. Report:
 - a. Prepare a written report covering monitoring performed and corrective action taken.
- B. Infrared Inspection: Perform the survey during periods of maximum possible loading. Remove covers prior to the inspection.

1. After Substantial Completion, but not more than 60 days after Final Acceptance, perform infrared inspection of the electrical power connections of the switchgear.
2. Instrument: Inspect distribution systems with imaging equipment capable of detecting a minimum temperature difference of 1deg C at 30 deg C.
3. Record of Infrared Inspection: Prepare a certified report that identifies the testing technician and equipment used and lists the results as follows:
 - a. Description of equipment to be tested.
 - b. Discrepancies.
 - c. Temperature difference between the area of concern and the reference area.
 - d. Probable cause of temperature difference.
 - e. Areas inspected. Identify inaccessible and unobservable areas and equipment.
 - f. Identify load conditions at time of inspection.
 - g. Provide photographs and thermograms of the deficient area.
4. Act on inspection results according to the recommendations of NETA ATS, Table 100.18. Correct possible and probable deficiencies as soon as Owner's operations permit. Retest until deficiencies are corrected.

3.8 DEMONSTRATION

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

END OF SECTION

SECTION 26 22 13

LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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.
- B. Sustainable Design Intent: Comply with project requirements intended to achieve sustainable design, measured and documented according to USGBC LEED-NC v4 rating system. Refer to Sections 01 81 10, SUSTAINABLE DESIGN REQUIREMENTS and 01 81 20 CONSTRUCTION INDOOR AIR QUALITY MANAGEMENT for additional requirements

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.
- B. Related Work: Consult all other Sections, determine the extent and character of related work and properly coordinate work specified herein with that specified elsewhere to produce a complete installation.
- C. REFERENCES

- 1. US Department of Energy, 10 CFR Part 431, April 18, 2013. Energy Conservation Program: Energy Conservation Standards for Distribution Transformers; Final Rule
- 2. DOE Test Method for Measuring the Energy Consumption of Distribution Transformers under Appendix A to Subpart K of 10 CFR part 431.
- 3. ANSI/NEMA ST 20 - Dry Type Transformers for General Applications.
- 4. NEMA Premium Efficiency Transformers Program
- 5. Consortium for Energy Efficiency (CEE): Specification for Low-Voltage, Dry-Type Distribution Transformers
- 6. EPACT 2005 - United States Energy Policy Act 2005 / NEMA TP1 - Guide for Determining Energy Efficiency for Distribution Transformers
- 7. ANSI/NEMA TP-2 – Standard Test Method for Measuring Energy Consumption of Distribution Transformers
- 8. Metering Standards:
- 9. Computational algorithms per IEEE Std 1459-2000
- 10. UL 916, UL 61010C-1 CAT III

11. IEEE C57.110-1998 – IEEE Recommended Practice for establishing transformer capability when feeding nonsinusoidal load currents
12. IEEE Std C57.12.91-1995 Standard Test Code for Dry-Type Transformers
13. IEEE-1100 – Recommended Practice for Powering and Grounding Sensitive Electronic Equipment

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Data/catalog cuts for each product and component specified herein, listing all physical and electrical characteristics and ratings indicating compliance with all listed standards.
2. Clearly mark on each data sheet the specific item(s) being submitted and the proposed application.
3. Include type and style, dimensions, insulation class, windings material, rated temperature rise, taps provided, voltage, KVA, BIL, unit weight, impedance ratings and characteristics, loss data, efficiency at 25, 50, 75 and 100 percent rated load, sound level and electrical test reports.
4. Insulation system impregnant data sheet as published by supplier.
5. Inrush Current (typical 3 cycle recovery)
6. Submit manufacturer's installation instructions.
7. Warranty 10 year limited upon issue of a "Certificate of Substantial Completion," by the Owner's Representative.
8. Efficiency data under load profile up to K20 at 25%, 50%, 75% and 100% of nameplate rating.
9. Test Reports per US DOE 10 CFR Part 431, NEMA TP2, of previously manufactured units – representative of the kVA range on the project, tested in ISO 17025 Certified Efficiency Test Lab, signed by test engineer, documenting history of production capability to comply with performance requirements of this specification.
10. Test Reports per factory ISO Nonlinear Load Test Program, signed by factory test engineer of previously manufactured units – representative of the kVA range on the project, tested in ISO 17025 Certified Efficiency Test Lab, documenting history of production capability to comply with performance requirement of this specification.
11. No load and full load losses per NEMA ST20
12. Linear load data @ 1/6 load
13. Linear load data @ 1/4, 1/2, 3/4 & full load
14. Linear Load efficiency @ 35% loading tested per NEMA TP-2.
15. Efficiency under K7 load profile @ 1/4, 1/2, 3/4 & full load of nameplate rating.

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. Source quality-control reports.
- C. 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 and handle in strict compliance with manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. Store so condensation will not form on or in the transformer housing and if necessary, apply temporary heat where required to obtain suitable service conditions.
 1. 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.
- C. Handling: Handle transformer using proper equipment for lifting and handling, use when necessary lifting eye and/or brackets provided for that purpose. 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. ABB/General Electric
 - 3. Square D; by Schneider Electric.
- B. Source Limitations: Obtain each transformer type from single source from single manufacturer.

2.2 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- B. Comply with NFPA 70.
- 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 use.
- D. 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.
 - 3. Copper-wound, 3-phase, common core, ventilated, dry-type, isolation transformer built to UL1561, NEMA ST20 and other relevant NEMA, UL and IEEE standards; 200% rated neutral; 60Hz rated; Transformers 750 kVA and less, 600 volt primary and less, 10kV BIL, shall be UL Listed and CSA Approved.
 - 4. All terminals, including those for changing taps, must be readily accessible by removing a front cover plate. Windings shall be continuous with terminations brazed or welded.
 - 5. Provide ground bar kit and neutral to ground bond jumper terminated at ground bar. Provide mechanical lugs mounted on the ground bar for input ground bond, output ground bond and external ground. Ground core & coil assembly to enclosure with a flexible copper grounding strap or equivalent.
 - 6. The neutral of the transformer shall be brought up to a lug and bolt inside of the case with the bolt extending outside so that the neutral can be grounded externally.
 - 7. Enclosures shall be fabricated of heavy gage sheet steel construction. Enclosure shall have suitable ventilating openings. Enclosure shall be provided with lifting lugs and jacking plates as required.
 - 8. Transformers shall be furnished complete with mounting channels and mounting bolts. Metal parts, excepting cores and core mounting frames shall be cleaned, rust-proofed and be given a heavy coating of an inert primer.
 - 9. Impedance: Between 3.5% and 5.8% unless otherwise noted.

10. Transformers shall have a minimum overload capacity per ANSI Standard. Certified temperature test of electrical duplicate units shall be supplied upon request.
11. Terminal compartments for both primary and secondary lines shall be located in the bottom of the transformer to ensure termination of cable leads in ambient temperature levels and to provide for side or bottom entrance of conduit.
12. Insulation System:
 - a. Shall be NOMEX-based with an Epoxy Co-polymer impregnant for lowest environmental impact, long term reliability and long life expectancy
 - b. Class: 220 degrees C
 - c. Impregnant Properties for low emissions during manufacturing, highest reliability and life expectancy.
 - d. Epoxy co-polymer
 - e. VOC: less than 1.65 lbs/gal (low emissions during manufacturing)
 - f. Water absorption (24hrs @25C): less than 0.05% (superior insulation, longer life)
 - g. Chemical Resistance: Must have documented excellent performance rating by supplier
 - h. Dielectric Strength: minimum of 3200 volts/mil dry (for superior stress, overvoltage tolerance)
 - i. Dissipation Factor: max. 0.02 @25C to reduce aging of insulation, extending useful life
13. All transformers shall have a basic impulse insulation level of 10 KV. The following tests shall be done at the factory:
 - a. Applied voltage test to each winding and from each winding to ground.
 - b. Induced voltage test - two times normal voltage.
 - c. Ratio, polarity and sound level: Sound level tests shall be performed in test rooms with an ambient sound level not exceeding 24 dBs.
14. Mounting:
 - a. Ventilated units up to 750 lbs.: Suitable for wall, floor or ceiling mounting (drip plate required).
 - b. Ventilated units over 750 lbs.: Suitable for floor mounting only.
15. EMF level, not to be higher than 10mG top, 10mG side and 10mG at one meter.

2.3 DISTRIBUTION TRANSFORMERS

- A. Copper-wound transformers meeting US Department of Energy 2016 mandated minimum efficiency. These transformers shall be UL listed to feed a K-13 electronic equipment load profile and be optimized to minimize operating cost under light loading.
- B. Core construction: high grade non-aging, fully processed silicon steel laminations and low hysteresis losses or better.

1. One leg per phase.
 2. Grounded to enclosure.
- C. Coil conductors: continuous copper windings, with terminations brazed or welded up to 75kVA and bolted 112.5 kVA and up. Anti-vibration pads shall be used between the core and the enclosure.
- D. Encapsulation: Transformers smaller than 30 kVA shall have core and coils completely resin encapsulated.
- E. Indoor Enclosure: Ventilated NEMA 2 enclosure designed to prevent hand or rod contact with live parts.
1. Core and coil shall be encapsulated within resin compound using a vacuum-pressure impregnation process 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.
- F. Outdoor Enclosure: Ventilated NEMA 4X Stainless Steel enclosure designed for protection in industrial or marine environment.
1. Core and coil shall be encapsulated within resin compound using a vacuum-pressure impregnation process to seal out moisture and air.
 2. Wiring Compartment: Sized for conduit entry and wiring installation.
 3. Finish: Comply with NEMA 250.
 - a. Finish Color: Gray weather-resistant enamel.
- G. Taps: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.
- H. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 80 deg C rise above 40 deg C ambient temperature.
- I. Grounding: Provide ground-bar kit or a ground bar installed on the inside of the transformer enclosure.
- J. 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.

- K. 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.
- L. Neutral: Rated 200 percent of full load current for K-factor-rated transformers.
- M. Wall Brackets: Manufacturer's standard brackets
- N. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:
 - 1. 9.01 to 15 kVA: 45 dBA.
 - 2. 30 to 50 kVA: 48 dBA for K-factors of 13
 - 3. 51 to 150 KVA: 53 dBA for K-factors of 13
 - 4. 150.01 to 300 kVA: 58 dBA for K-factors of 13
 - 5. 300.01 to 500 kVA: 63 dBA for K-factors of 13
 - 6. 500.01 to 700.00: 65 dBA for K-factors of 13
 - 7. 700.01 to 1000.00: 67 dBA for K-factors of 13

2.4 IDENTIFICATION

- A. Nameplates: Engraved, laminated-acrylic signs for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 26 05 53 "Identification for Electrical Systems."

2.5 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. Thoroughly examine site conditions for acceptance of transformer installation to verify conformance with manufacturer and specification tolerances. Do not commence with installation until all conditions are made satisfactory.
- B. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- C. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- D. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- E. Verify that ground connections are in place and requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- F. 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.
- G. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Ensure all conduit stub-ups for bottom entry into transformer are in place and located as required per shop drawings.
- B. Provide a 4" high concrete housekeeping pad beneath equipment. Coordinate actual sizes of equipment base with shop drawings and extend pad 3" in all directions beyond overall dimension of base. Provide reinforcing bars as required structurally within pad to insure proper support of equipment.

3.3 INSTALLATION

- A. 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.

- B. Construct concrete bases according to Section 03 30 00 "Cast-in-Place Concrete" and anchor floor-mounted transformers according to manufacturer's written instructions and requirements in Section 26 05 29 "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.
- C. Secure transformer to concrete base according to manufacturer's written instructions.
- D. Secure covers to enclosure and tighten all bolts to manufacturer-recommended torques to reduce noise generation.
- E. Remove shipping bolts, blocking, and wedges.

3.4 CONNECTIONS

- A. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 26 05 19 "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 metallic conduit connections, minimum 24 inch length, with external grounding jumper at all conduit and conductor terminations and supports to eliminate sound and vibration transmission to the building structure.
- E. Vibration isolators shall be provided between trapeze or hangers of ceiling mounted transformers and its case and between transformer case and concrete base for floor mounted units.
- F. Vibration isolators shall be provided to isolate the transformer case from the core and coil assembly.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. 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.
- C. Remove and replace units that do not pass tests or inspections and retest as specified above.
- D. 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.
- E. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.6 ADJUSTING

- A. The Contractor shall set the taps on all transformers, which are a part of this contract as necessary to provide satisfactory operating voltages with all present loads energized, including the new loads and any existing loads. The Contractor shall check voltages, in the presence of the owner's representative, before the building is occupied and change taps where required.
- B. The Contractor shall provide all instruments and accessories required to perform the checks. Voltmeters shall be accurate with 3/4 or 1% and shall have scales

permitting the voltage readings to be made on the upper half of the scale. Calibration of the meters shall be satisfactory to the owner.

- C. 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.
- D. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.7 CLEANING

- A. Prior to energizing of transformer the contractor shall thoroughly clean the interior of enclosure of all construction debris, scrap wire, etc. using manufacturer's approved methods and materials.
- B. Upon completion of project prior to final acceptance the contractor shall thoroughly clean both the interior and exterior of transformer per manufacturers recommended materials and methods. Remove paint splatters and other spots, dirt, and debris.
- C. Touch-up paint any marks, blemishes, or other finish damage suffered during installation.

END OF SECTION

SECTION 26 24 13

SWITCHBOARDS

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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.
- B. Related Work: Consult all other Sections, determine the extent and character of related work and properly coordinate work specified herein with that specified elsewhere to produce a complete installation.

1.2 SUMMARY

- A. Section Includes:
 - 1. Service and distribution switchboards rated 600 V and less.
 - 2. Surge protection devices.
 - 3. Disconnecting and overcurrent protective devices.
 - 4. Instrumentation.
 - 5. Control power.
 - 6. Accessory components and features.
 - 7. Identification.
- B. Related Requirements
 - 1. Section 26 05 73 "Overcurrent Protective Device Coordination Study and Arc Flash Hazard Analysis" for arc-flash analysis and arc-flash label requirements.

1.3 REFERENCES

- A. Comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:
 - 1. UL 486A Wire Connectors and Soldering Lugs for use with Copper Conductors
 - 2. UL 489 Molded- Case Circuit Breakers and Circuit Breaker Enclosures
 - 3. UL 891 Dead-Front Electrical Switchboards
 - 4. ANSI C12 Code for Electricity Metering

5. ANSI C39.1 Requirements for Electrical Analog Indicating Instruments
6. ANSI C57.13 Requirements for Instrument Transformers
7. FS W-C-375 Circuit Breakers Molded Case, Branch Circuit and Service
8. NEMA AB 1 Molded Case Circuit Breakers
9. NEMA PB 2 Dead Front Distribution Switchboards
10. NEMA PB 2.1 Instructions for Safe Handling, Installation, Operation and Maintenance of Deadfront Switchboards Rated 600 Volts or less

1.4 ACTION SUBMITTALS

- A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.
 1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 2. Provide a matrix including the following Switchboard name, Fed From, phase, voltage, current, wiring configuration, short circuit rating, schedule drawing number and room location.
- 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.
 - a. Front, plan and side view elevations with overall dimensions.
 - b. Conduit entrance locations and requirements
 - c. Nameplate legends; size and number of bus bars per phase, neutral, and ground
 - d. Switchboard instrument details and accessories
 - e. Single line & schematic diagrams.
 2. Detail enclosure types for types other than NEMA 250, Type 1.
 3. Detail bus configuration, current, and voltage ratings.
 4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 6. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.
 7. Include schematic and wiring diagrams for power, signal, and control wiring.
 8. Submit manufacturer's installation instructions.
 9. Complete Bill of Material listing all components.
- C. The equipment selections used in the preparation of the Contract Documents will fit into the physical spaces provided and indicated, allowing ample room for access, servicing, removal and replacement of parts, etc. Adequate space shall be allowed for clearance in accordance with Code requirements, the requirements of the Authorities Having Jurisdiction, and the equipment manufacturer's recommendations.

- D. In the preparation of Drawings, a reasonable effort to accommodate acceptable equipment manufacturer's space requirements has been made. However, since space requirements and equipment arrangement vary according to each manufacturer, the responsibility for initial access, maintenance access, code required access, and proper fit rests with the Contractor.
- E. The work described in any shop drawing submission shall be carefully checked by this Contractor for all clearances, including those required for maintenance, servicing equipment removal, field conditions, maintenance of architectural conditions and proper coordination with all Trades on the job. Each submitted shop drawing shall include a certification by the Contractor that all related job conditions have been checked and that no conflict exists. No shop drawing submission will be reviewed without such certification.
- F. Delegated Design Submittal:
 - 1. For arc-flash hazard analysis.
 - 2. For arc-flash labels.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Field Quality-Control Reports:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 01 10 00 "General Requirements," include the following:
 - a. Routine maintenance requirements for switchboards and all installed components.
 - b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.

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. 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. Indicating Lights: Equal to 10 percent of quantity installed for each size and type but no less than two of each size and type.
 - 4. Surge Protection Devices: For modular SPDs, provide one complete set of replacement SPD protection modules for each SPD installed, including all phase, neutral, and ground modules.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.
- B. Testing Agency Qualifications: Accredited by NETA.
 - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Delivery: Switchboard components shall not be delivered to the site until protected storage space is available. Storage outdoors covered by rainproof material is not acceptable. Equipment damaged during shipment shall be replaced and returned to manufacturer at no additional cost to the Owner's Representative. Components shall be properly packaged in factory-fabricated containers and mounted on shipping skids. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
- B. Storage: Store in a clean, dry, ventilated space free from temperature extremes. Maintain factory wrapping or provide a heavy canvas/plastic cover to protect units from dirt, water, construction debris, and traffic. Provide heat where required to prevent condensation.
- C. Handling: Handle and prepare switchboards for installation according to NEMA PB 2.1 and manufacturer's written instructions. Be careful to prevent internal component damage, breakage, denting and scoring. Damaged units shall not be installed. Replace damaged units and return equipment to manufacturer.

1.10 FIELD CONDITIONS

- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.
- B. Environmental Limitations:
 - 1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary or permanent 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 104 deg F .
 - b. Altitude: Not exceeding 6600 feet .

1.11 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. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.12 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: 3 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SWITCHBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB/General Electric
 - 2. Eaton Cutler Hammer

3. Square D; by Schneider Electric.
- 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 as defined in NFPA 70, by a qualified testing agency, 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. The assembly shall be rated to withstand mechanical forces exerted during short-circuit conditions when connected directly to a power source having available fault current at rated voltage as noted on the drawings.
- J. Voltage and current ratings shall be as indicated on the drawings.
- K. Indoor Enclosures: Steel, NEMA 250, Type 1.
 1. Switchboards shall be fully self-supporting structures with 90 inch tall vertical sections (excluding lifting eyes and pull boxes) bolted together to form required arrangement.
 2. Switchboard frame shall be die formed, 12 gauge steel with reinforced corner gussets. Frame shall be rigidly bolted to support cover plates code gauge steel, bus bars and installed devices during shipment and installation. C.
The assembly shall be provided with adequate lifting means.
 3. All sections may be rolled, moved or lifted into position. Switchboards shall be capable of being bolted directly to the floor without the use of floor sills.
 4. All switchboard sections shall have open bottoms and removable top plate(s) to install conduit.
 5. Front-Access only switchboard sections shall be front and rear aligned for placement against a wall.
 6. Switchboards shall be UL listed.
 7. All covers shall be fastened by hex head bolts.
 8. Provide hinged doors over metering compartments and individually mounted device compartments. All doors shall have concealed hinges and be fastened by hex head bolts.

9. Switchboard protective devices shall be furnished as listed on drawings and specified herein, including interconnections, instrumentation and control wiring.
 10. Switchboard current ratings, including all devices, shall be based on a maximum ambient temperature of 25 degree C per UL Standard 891. With no derating required, temperature rise of switchboards and devices shall not exceed 65 degrees C in a 25 degree C ambient environment.
 11. Mounting for the group mounted devices shall be by bolted connections. No plug-in type connections shall be used for current carrying components.
- L. Enclosure Finish for Indoor Units:
1. All metal structural and unit parts shall be completely painted so that interior and exterior surfaces have a complete finish coat on and between them.
 2. Enclosure shall be thoroughly cleaned, rinsed, pretreated with phosphatizing process followed by sealer rinses and rust inhibitor process and painting.
 3. Paint shall be UL recognized acrylic, baked enamel ANSI-61 light gray.
- M. Barriers: Between adjacent switchboard sections for emergency switchboards only.
- N. Isolation for main and vertical buses of feeder sections.
- O. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- P. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- Q. 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 the front of the switchboard.
 2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated. The bus bars shall have sufficient cross-sectional area to meet UL 891 temperature rise requirements. Phase and neutral bus ampacity shall be as shown on the plans.
 3. Bus bars shall be mounted on high impact, non-tracking insulated supports. Joints in the vertical bus are not permitted.
 4. Bus bars shall be braced to withstand mechanical forces exerted during short circuit conditions as indicated in drawings, but in no case less than 65KA RMS SYM.
 5. Bus joints shall be bolted with high tensile steel Grade 5 bolts. Welded connections are unacceptable.
 6. All hardware used on conductors shall be high-tensile strength and zinc-plated. All bus joints shall be provided with conical spring-type washers.
 7. All feeder device line and load connection straps shall be rated to carry current rating of device frame not trip rating.
 8. The main incoming bus bars shall be rated for the main overcurrent protection device switch or frame size and not less than the main incoming conductors.
 9. Copper feeder circuit-breaker line connections.

10. Load Terminals: Rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
 11. Ground Bus shall be sized to meet UL 891. Ground bus shall extend full length of switchboard. Ground bus shall be copper hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors.
 12. 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.
 13. 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.
 14. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
 15. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
- R. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.2 SURGE PROTECTION DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB (Electrification Products Division).
 2. Eaton.
 3. Square D; by Schneider Electric.
- B. The SPD shall be listed as Type 1 SPD, suitable for use in UL 1449, Type 1 OR Type 2 applications.
- C. Surge Protection Device Description: Modular design with field-replaceable module mounted externally to the Switchboard, with EMI Filtering (also known as sine-wave-tracking) type with the following features and accessories:
1. Fuses, rated at 200-kA interrupting capacity (AIC).
 2. Fabrication using bolted compression lugs for internal wiring.
 3. Integral disconnect capable of passing full rated surge current, or dedicated fuse or breaker.
 4. Multiple suppression circuits with current sharing.
 5. Field Replaceable protection module.
 6. Utilizing wire connections to phase buses, neutral bus, and ground bus.
 7. LED indicator lights for power and protection status.
 8. Monitoring system capable of indicating the number of transient surges, over voltages, under voltage events.

9. Audible alarm, with silencing switch, to indicate when protection has failed.
 10. Dual set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with the building power monitoring and control system.
 11. Field testable with test data from factory provided for comparison
 12. Senses percentage of protection available indicating true protection level available
 13. Monitors neutral-to-ground voltage and current
- D. Peak Surge Current Rating:
1. 480/277V switchboards, 1200A or larger: 240 kA
- E. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V or 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
1. Line to Neutral: 800 V for 480Y/277 V.
 2. Line to Ground: 800 V for 480Y/277 V.
 1. Line to Line: 800 V for 480Y/277 V.
- F. Nominal Rating: 20 kA.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Main Devices

1. Main device 1200 Amps and larger shall be individually mounted, manually operated, stationary mounted and insulated case circuit breaker.
2. All circuit protective devices shall have the following minimum symmetrical current interrupting capacity: 100kA or as listed on the contract drawings.

B. Feeder Devices

1. Feeder devices shall be group mount molded case circuit breakers.
2. Circuit breakers shall have digital electronic trip functions where indicated on the drawings.
3. Adjustable magnetic trip setting for circuit-breaker frame sizes 200 amps and smaller.

C. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Furnish RMS Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting. Adjustable magnetic trip setting for circuit-breaker frame sizes 125 A and smaller.

3. Group mounted breakers shall be connected to the vertical bus by bolted connections.
4. Individually mounted molded case circuit breakers shall be stationary mounted.
5. Circuit breaker frames shall be constructed of a high-strength, molded, glass-reinforced polyester case and cover. Breakers shall have an overcenter, toggle handle-operated, trip free mechanism with quick make, and quick break action independent of the speed of the toggle handle operation. The design shall provide common tripping of all poles. Breakers shall be suitable for reverse feeding.
6. Breakers shall have ON and OFF position clearly marked on escutcheon. Breakers shall include a trip-to-test means on the escutcheon for manually tripping the breaker and exercising the mechanism and trip latch.
7. Breakers shall include factory installed mechanical lugs. Lugs shall be UL listed and rated 75 degrees C.
8. Where indicated on drawings, circuit breakers shall have digital electronic trip functions with the following characteristics;
 - a. Furnish digital electronic trip units as specified below.
 - b. The protective trip unit shall consist of a solid state, microprocessor based programmer; tripping means; current sensors; power supply and other devices as required for proper operation.
 - c. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
 - 1) Instantaneous trip.
 - 2) Long- and short-time pickup levels.
 - 3) Long and short time adjustments.
 - 4) Ground-fault pickup level, time delay, and I^2t response where indicated on contract drawings.
 - d. As a minimum, the trip unit shall include the following features:
 - 1) Long time and short time protective functions shall have true RMS sensing technology.
 - 2) Ground fault protective function, if provided, shall contain a memory circuit to integrate low level arcing fault currents with time, to sum the intermittent ground fault spikes.
 - a) High contrast liquid crystal display (LCD) unit shall display settings, trip targets, and the specified metering displays.
 - b) Multi-button keypad to provide local setup and readout of all trip settings on the LCD.
 - c) UL Listed interchangeable rating plug. It shall not be necessary to remove the trip unit to change the rating plug.
 - d) An integral test jack for testing via a portable test set and connection to a battery source.
 - e) A mechanism for sealing the rating plug and the trip unit.
 - f) Noise immunity shall meet the requirements of IEEE C37.90.
 - g) Display trip targets for long time, short time, and ground fault, if included.

- 3) Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
9. Current-Limiting Circuit Breakers: Frame sizes 200A and smaller; let-through ratings less than NEMA FU 1, RK-5.
10. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
11. MCCB Features and Accessories:
 - a. Lugs: Mechanical style, suitable for number and size of conductors indicated on the single line diagram, trip ratings, and conductor material.
 - b. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - c. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator where indicated on contract drawings.
 - d. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - e. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
- D. Insulated-Case Circuit Breaker (ICCB): Cutler-Hammer type Magnum SBSE or approved equal, fuse-less current limiting type with fast opening 100 percent rated, sealed, insulated-case power circuit breaker with 200,000-ampere rms symmetrical interrupting capacity rating or as noted on drawing to meet available fault current.
 1. Draw-out circuit-breaker mounting.
 2. Two-step, stored-energy closing.
 3. Each circuit breaker shall be equipped with a solid-state tripping system consisting of three (3) current sensors, microprocessor-based trip device and flux-transfer shunt trip. Current sensors shall provide operation and signal function. The trip unit shall use microprocessor-based technology to provide the basic adjustable time/current protection functions. True rms sensing circuit protection shall be achieved by analyzing the secondary current signals received from the circuit breaker current sensors, and initiating trip signals to the circuit breaker trip actuators when predetermined trip levels and time-delay settings are reached.
 4. Full-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.
 - c. Ground-fault pickup level, time delay, and I squared t response where indicated on drawings
 5. Remote trip indication.
 6. Control Voltage: 120-V ac.

7. Breakers shall be constructed of a high dielectric strength, glass reinforced insulating case. The interrupting mechanism shall be arc chutes. Steel vent grids shall be used to suppress arcs and cool vented gases. Inter-phase barriers shall isolate completely each pole.
8. Breakers shall contain a true two-step stored energy operating mechanism which shall provide quick make, quick break operation with a maximum five cycle closing time. Breakers shall be trip free at all times. Common tripping of all poles shall be standard.
9. A charging handle, close push-button, open push-button, and Off/On/Charge indicator shall be located on the breaker escutcheon and shall be visible with the breaker compartment door closed.
10. To ensure a selective system, all circuit breakers shall have 30-cycle short-time withstand ratings equal to 18 times their frame ratings. Insulated case circuit breakers without an instantaneous trip element adjustment shall be equipped with a fixed internal instantaneous override set at that level.

2.4 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 switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

2.5 IDENTIFICATION

- A. Equipment Identification Description, refer to Section 26 05 53.
- B. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads. Include as-built data for low-voltage power switchgear and connections as follows:
 1. Frame size of each circuit breaker.
 2. Trip rating for each circuit breaker.
 3. Conduit and wire size for each feeder.
- C. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices, refer to drawings for requirement.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.

1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's 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 per manufacturer's 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 the performance of the equipment.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install switchboards and accessories according to NEMA PB 2.1.
- B. Equipment Mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Section 03 30 00 "Cast-in-Place Concrete."
1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches (50-mm) above concrete base after switchboard is anchored in place.
 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the 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 switchboards.
 6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.
- D. Operating Instructions: Frame and mount the 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.

- E. Install filler plates in unused spaces of panel-mounted sections. All switchboard spaces shall be provided with bussing and hardware required for future circuit breaker attachment
- F. Install overcurrent protective devices, surge protection devices, and instrumentation.
 - 1. Set field-adjustable switches and circuit-breaker trip ranges.
- G. Comply with NECA 1.

3.3 CONNECTIONS

- A. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.
- B. Support and secure conductors within the switchboard according to NFPA 70.
- C. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.4 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."
- B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 26 05 53 "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 a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. 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 the 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 per NFPA 70.
 3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 4. All breakers shall be tested at the settings specified in approved Coordination Study by primary injection method per NETA ATS.
 5. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 6. 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 switchboard. 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 switchboard 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.
 7. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Switchboard will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Submit final report for review prior to project closeout and final acceptance by the owner. Include notation of test dates, devices tested, deficiencies detected, remedial action taken, and observations after remedial action.

3.6 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 26 05 73 Coordination Studies.

3.7 PROTECTION

- A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

END OF SECTION

SECTION 26 24 16

PANELBOARDS

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.
 - 3. Load centers.

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.
 1. Short-circuit current rating of panelboards and overcurrent protective devices.
 2. Include evidence of NRTL listing for SPD as installed in panelboard.
 3. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 4. Include wiring diagrams for power, signal, and control wiring.
 5. Key interlock scheme drawing and sequence of operations.
 6. 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.
 7. Provide a matrix including the following Panel Name, Fed From, phase, voltage, current, wiring configuration, short circuit rating, panel schedule drawing number and room location.
- C. The equipment selections used in the preparation of the Contract Documents will fit into the physical spaces provided and indicated, allowing ample room for access, servicing, removal and replacement of parts, etc. Adequate space shall be allowed for clearance in accordance with Code requirements, the requirements of the Authorities Having Jurisdiction, and the equipment manufacturer's recommendations.
- D. In the preparation of Drawings, a reasonable effort to accommodate acceptable equipment manufacturer's space requirements has been made. However, since space requirements and equipment arrangement vary according to each manufacturer, the responsibility for initial access, maintenance access, code required access, and proper fit rests with the Contractor.
- E. The work described in any shop drawing submission shall be carefully checked by this Contractor for all clearances, including those required for maintenance, servicing equipment removal, field conditions, maintenance of architectural conditions and proper coordination with all Trades on the job. Each submitted shop drawing shall include a certification by the Contractor that all related job conditions have been checked and that no conflict exists. No shop drawing submission will be reviewed without such certification.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.

B. Field Quality-Control Reports:

1. Test procedures used.
2. Test results that comply with requirements.
3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

C. 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 010000 "Consolidated Gen Requirements," 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. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.8 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or ISO 9002 certified.

B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

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.

B. Handle and prepare panelboards for installation according to NEMA PB 1.

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 23 deg F (minus 5 deg C) to plus 104 deg F (plus 40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2000 m).

1.11 COORDINATION

- 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.

1.12 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 AND LOAD CENTERS COMMON REQUIREMENTS

- A. 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.
- 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 NEMA PB 1.
- D. Comply with NFPA 70.
- E. Enclosures: Flush and Surface-mounted, dead-front cabinets.
 - 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b. Outdoor Locations: NEMA 250, Type 4X, stainless Steel.
 - c. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 - d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - e. Indoor Mechanical Locations: NEMA 250, Type 12.
 - 2. Height: 84 inches (2.13 m) maximum.
 - 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged.
 - 4. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
 - 5. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
 - 6. 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.
 - 7. Directory Card: Inside panelboard door, mounted in metal frame with transparent protective cover.
- F. Incoming Mains:
 - 1. Location: Top or bottom to suit incoming feeder.
 - 2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.
- G. Phase, Neutral, and Ground Buses:
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 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.

- H. Conductor Connectors: Suitable for use with conductor material and sizes.
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 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: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
 - 5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
 - 6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 - 7. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 - 8. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material and with matching insulating covers. Locate at same end of bus as incoming lugs or main device.
- I. 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: As shown on drawings and schedules.
- J. 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.

2.2 PERFORMANCE REQUIREMENTS

- A. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 2.

2.3 DISTRIBUTION PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Cutler Hammer.
 - 2. ABB/General Electric ABB.
 - 3. Square D; a brand of Schneider Electric.
- B. Panelboards: NEMA PB 1, distribution type.
- C. Enclosures

1. Panel box shall be galvanized code gauge sheet steel with removable end walls.
2. Enclosures shall be surface mounted.

D. Fronts

1. Provide a four piece front to cover wiring gutter and wiring access areas.
2. Hinged door fronts shall be provided with door-in-door.
3. An inner door shall cover the circuit protective devices and shall be able to be locked.
4. Door locks shall be Yale 511, if available.

E. Interiors

1. Panelboard interior shall be designed and assembled such that circuit protective devices shall be solidly connected to the distribution panel vertical bus. The bus bars shall be attached to the feeder device by bolts and to the vertical bus by bolts and anti-turn methods.
2. Circuit breaker connectors shall be designed so that circuit breakers may be removed without disturbing adjacent devices.
3. Panelboards shall be rated as indicated in drawings.
4. Panelboards shall have three vertically aligned bus bars.
5. Bus bars shall be copper. The bus bars shall have sufficient cross-sectional area to meet UL 67 temperature rise requirements through actual tests.
6. Bus bars shall be phase-sequenced and rigidly supported by high impact resistant, insulated bus supporting assemblies to prevent vibration or short circuit mechanical damage.
7. Neutral bus shall be fully rated.
8. All solderless terminations shall be suitable for copper UL listed wire or cable and shall be tested and listed in conjunction with appropriate UL standards. Terminations shall be rated for use with conductor ampacity as assigned in the NEC 75 degree C table.
9. Ground wire terminations shall be provided as an optional kit for installation by panelboard installer without voiding UL label.

F. Main and Branch Devices

1. Main and branch circuit breakers shall be RMS circuit breaker.
2. Adjustable magnetic trip setting for circuit-breaker trip rating smaller than 400 amps.
3. Circuit breakers with trip ratings 400 amps and larger and other circuit breakers where indicated on the drawings shall have digital electronic trip functions with the following characteristics:
 - a. Electronic true RMS sensing trip, adjustable via current plug.
 - b. Long-Time pickup & delay
 - c. Short-time pickup & delay
 - d. Instantaneous trip.
 - e. Ground Fault pickup level, time delay trip where indicated on drawing

4. Single pole branch circuit breakers shall be quick-make, quick break, and trip indicating, molded-case circuit breaker and shall not exceed 10% of the total number of poles.
5. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
6. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
7. Circuit breaker case shall have ON/OFF and International I/O position indicators.
8. Breaker faceplate shall list current rating, UL and IEC certification standards, and AIC ratings.
9. Circuit breakers shall be factory sealed and shall be date coded on breaker case.
10. Breakers shall be UL listed for reverse connection without restrictive line or load markings. Circuit breakers shall be able to mount in any operating position.
11. All circuit protective devices shall have a short circuit interrupting capacity as shown on the plans.
12. Main breakers and lugs shall be convertible by installer for top or bottom incoming feed.
13. MCCB Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Breaker handle indicates tripped status.
 - c. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
 - d. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
 - e. Ground-Fault Protection: Remote-mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator, where indicated on drawings.
 - f. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage, where indicated on drawings.
 - g. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay, where indicated on drawings.
 - h. Auxiliary Contacts: Two, SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
 - i. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips, where indicated on drawings.
 - j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position, where indicated on drawings.
 - k. Multipole units enclosed in a single housing with a single handle.
 - l. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in off position.
 - m. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Cutler Hammer.
 - 2. ABB/General Electric ABB.
 - 3. Square D; a brand of Schneider Electric.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- D. Ratings
 - 1. Lighting and appliance panelboards shall be rated as indicated in drawings.
 - 2. Maximum current ratings for mains, sub-feeds and branches, respectively, shall be as specified in drawings.
- E. Enclosure
 - 1. Boxes shall be a nominal 20 inches wide and 6 inches deep with wire bending space per National Electric Code.
 - 2. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.
 - 3. All door locks shall be corrosion proof with retractable latches and shall be keyed for a single key.
 - 4. Interiors shall permit top or bottom incoming cables.
- F. Bus bars
 - 1. The bus bars shall be phase sequenced, fully insulated and supported by high impact Noryl (or equal) interior base assemblies.
 - 2. Bus bars shall be fabricated using copper with minimum bus size of 225Amps.
 - 3. Copper bus bars shall have sufficient cross-sectional area to meet UL 67 temperature rise requirements through actual tests to provide a current density of 1000A per square inch.
 - 4. Bus bars shall be mechanically supported by zinc finished galvanneal steel frames to prevent vibration and damage from short circuits.
 - 5. Terminations shall be UL tested and listed and suitable for UL copper wire.
 - 6. Provide [1] continuous bus bar per phase. Each bus bar shall have sequentially phased branch circuit connectors for bolt-on branch circuit breakers.
 - 7. Split solid neutral bus shall be plated and located in main compartment for all incoming neutral cables to be same length.
 - 8. Two hundred percent (200%) rated neutral shall be provided on 120/208V panels where indicated on schedules or contract drawings.

9. Lugs shall be rated for 75 degree C terminations.
10. Main lugs for copper conductors shall be bolted compression lugs.
11. Lug bodies shall bolt in place, suitable for number, size, trip ratings, and conductor material.

G. Circuit Breakers

1. The Main circuit breakers shall be RMS circuit breaker.
2. Branch devices molded case circuit breakers shall be bolt-on devices.
3. Adjustable magnetic trip setting for circuit-breaker trip rating sizes smaller than 400 amps.
4. Circuit breakers with trip ratings 400 amps and larger and other circuit breakers where indicated on the drawings shall have digital electronic trip functions with the following characteristics:
 - a. Electronic true RMS sensing trip, adjustable via current plug.
 - b. Long-Time pickup & delay
 - c. Short-time pickup & delay
 - d. Instantaneous trip.
 - e. Ground-fault pickup where indicated on drawing
5. All circuit breakers shall have thermal and magnetic trip elements in each pole.
6. Two and three pole breakers shall have internal common trip crossbars for simultaneous tripping of each pole.
7. Circuit breakers shall not be restricted to any mounting location due to physical size.
8. Main and sub-feed circuit breakers may be vertically or horizontally mounted.
9. Branch breaker panelboard connections shall be copper to copper.
10. All panelboard terminations shall be rated as indicated in drawings.
11. All breakers shall have an over center mechanism and be quick make and quick break.
12. All breakers shall have handle trip indication and a trip indicator in window of circuit breaker housing.
13. Breaker handle and faceplate shall indicate rated ampacity.
14. Circuit breaker escutcheon shall have standard ON/OFF markings.
15. Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits
16. HACR Type circuit breaker for use with motor, heating, air-conditioning and refrigeration equipment, with the UL Mark.
17. Where indicated in schedules provide the following type CB:
 - a. Current-Limiting Circuit Breakers: Frame sizes 200 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 - b. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 - c. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
 - d. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
18. Breaker faceplate shall list current rating, UL and IEC certification standards, and AIC ratings.

19. All circuit protective devices shall have a short circuit interrupting capacity as shown on the plans.
20. Main breakers and lugs shall be convertible by installer for top or bottom incoming feed.
21. MCCB Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Breaker handle indicates tripped status.
 - c. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
 - d. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.
 - e. Ground-Fault Protection: Remote-mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator, where indicated on drawings.
 - f. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage, where indicated on drawings.
 - g. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay, where indicated on drawings.
 - h. Auxiliary Contacts: Two, SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts, where indicated on drawings.
 - i. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips, where indicated on drawings.
 - j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position, where indicated on drawings.
 - k. Multipole units enclosed in a single housing with a single handle.
 - l. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in off position.
 - m. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.5 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: 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.

2.6 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 NEMA PB 1.1.
- 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 NEMA PB 1.1.
- D. Surface-mounted panelboard cabinets shall be rigidly supported in place independent of the conduits with two rows of Unistrut. Set panels plumb and symmetrical with building lines. Furnish and install all construction channel bolts, angles, etc., required to mount the equipment furnished under this Section.
- E. Mounting height shall be 7'-6" to top of panelboard or 6'-6" to the centerline of highest mounted breaker handle.

- F. Provide mounting hardware brackets, busbar drillings and filler pieces for all unused spaces.
- G. Mount panelboard cabinet plumb and rigid without distortion of box.
- H. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- I. Replace panel pieces, doors, or trim exhibiting dents, bends, warps or poor fit that may impede ready access, security or integrity.
- J. Conduits terminating in concentric, eccentric or oversized knockouts at panelboards shall have ground bushings and bonding jumpers installed interconnecting all such conduits and the panelboard.
- K. Check and tighten all bolts and connections with a torque wrench using manufacturer's recommended values.
- L. Provide two 1" and two 3/4" spare conduits stubbed-out of flush mounted panelboards to the nearest accessible ceiling space or other accessible location and cap for future use.
- M. Visually inspect panelboard for rust and corrosion. If signs of rust and corrosion are present, restore or replace panelboard to new condition.
- N. In damp and wet locations mount panelboards with a minimum one inch of air space between cabinet and the wall or other supports.
- O. All surfaces of surface mounting cabinets and fronts shall be given one coat of metal primer and a finish coat of baked on gray enamel.
- P. Panelboards located in mechanical areas shall be NEMA 12 with weatherproof gaskets on trims and doors.
- Q. Provide close up plugs in all unused openings in the cabinet.
- R. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- S. Equipment Mounting:
 - 1. Install panelboards 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. Attach panelboard to the vertical finished or structural surface behind the panelboard.
- T. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

- U. 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.
- V. Install filler plates in unused spaces.
- W. Arrange conductors in gutters into groups and bundle and wrap with wire ties

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. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers and low-voltage surge arrestors stated in NETA ATS, Paragraph 7.6 Circuit Breakers and Paragraph 7.19.1 Surge Arrestors, Low-Voltage. 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.
- D. Panelboards will be considered defective if they do not pass tests and inspections.
- E. 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 "Overcurrent Protective Device Coordination Study and Arc Flash Hazard Analysis."

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 26 27 26

WIRING DEVICES

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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, but is not limited to:
 - 1. Standard-grade receptacles
 - 2. USB receptacles.
 - 3. GFCI receptacles.
 - 4. Tamper-resistant receptacles.
 - 5. Weather-resistant receptacles.
 - 6. Twist-locking receptacles.
 - 7. Pendant cord-connector devices.
 - 8. Toggle switches
 - 9. Decorator-style devices
 - 10. Wall plates.

1.3 DEFINITIONS

- A. AFCI: Arc-fault circuit interrupter.
- B. BAS: Building automation system.
- C. EMI: Electromagnetic interference.
- D. GFCI: Ground-fault circuit interrupter.
- E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- F. RFI: Radio-frequency interference.
- G. SPD: Surge protective device.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Data/catalog cuts for each product and component specified herein, listing all physical and electrical characteristics and ratings indicating compliance with all listed standards.
 - 2. Clearly mark on each data sheet the specific item(s) being submitted and the proposed application.
 - 3. Provide color finishes for Owner's Representative/Architect to select from.
 - 4. Submit manufacturer's installation instructions.
 - 5. Where engraved device cover plates are noted on the drawings or in the specifications, conform to the requirements of Section 26 05 53.
- B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.
- C. Submit a wiring device matrix for approval by the Owner's Representative/Architect indicating the following:
 - 1. List device type and the associated cover type, space type installed in (e.g. office, pantry, corridor, gallery, outdoor, etc.), and color.
- D. Submit a floor box/poke thru assembly matrix for approval by the Owner's Representative/Architect indicating the following:
 - 1. Room number, room name; floor type; floor finish; quantity of receptacles outlets/gangs; quantity of tele/data gangs/devices; cover color and cover finish.
- E. Samples for Custom Colors & Engraving: 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.

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. Duplex receptacles: 5 units.

2. GFCI receptacles: 5 units
3. Weather-resistant receptacles: 3 units
4. Toggle switches: 5 units
5. Wallplates: 10 units (assorted, single-gang, multi-gang).
6. USB receptacles: 3 units

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Wiring Devices:
 - a. Hubbell Incorporated; Wiring Device-Kellems.
 - b. Leviton Mfg. Company Inc.
 - c. Pass & Seymour/Legrand; Wiring Devices Div.
2. Multioutlet Assemblies:
 - a. Hubbell Incorporated; Wiring Device-Kellems.
 - b. Leviton Mfg. Company Inc.
 - c. Pass & Seymour/Legrand; Wiring Devices Div.
3. Poke-Through and Floor Service Outlets:
 - a. Hubbell Incorporated; Wiring Device-Kellems.
 - b. Pass & Seymour/Legrand; Wiring Devices Div.
 - c. Square D/Groupe Schneider NA.
 - d. Thomas & Betts Corporation.
 - e. Wiremold Company (The).

2.2 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. NEMA WD 2 Semiconductor Dimmers for Incandescent Lamps
- F. NEMA WD 5 Specific-Purpose Wiring Devices
- G. NEMA WD 6 Wiring Device Configurations
- H. NEMA 250 Enclosures for Electrical Equipment

- I. 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.
- J. Devices for Owner-Furnished Equipment:
 - 1. Receptacles: Match plug configurations.
 - 2. Cord and Plug Sets: Match equipment requirements.
- K. Wall Plate & Device Color:
 - 1. Refer to Section "26 05 53 Identification for Electrical Systems" for system colors and engraving.
 - 2. In general covers shall match the device cover, unless otherwise noted.
 - 3. Provide custom cover colors as selected by the Architect.
 - 4. Normal power receptacles shall be white with white faceplate (coordinate with Architect).
 - 5. Emergency power receptacles shall be red with red faceplate.
- L. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.3 STRAIGHT BLADE RECEPTACLES, 125 V, 20 A

A. Convenience Receptacles, 125 V, 20 A

- 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the work include, but are not limited to, the following:
 - a. Cooper; 5351 (single), CR5362 (duplex).
 - b. Hubbell; HBL5361 (single), HBL5362 (duplex).
 - c. Leviton; 5361 (single), 5362 (duplex).
 - d. Pass & Seymour; 5361 (single), 5362A (duplex).
- 2. Description: 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. Tamper-Resistant Duplex Receptacles, 125 V, 20 A:

- 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the work include, but are not limited to, the following:
 - a. Hubbell; BR20TR.
 - b. Leviton; TBR20.
 - c. Pass & Seymour; TR63.

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. Weather-Resistant Duplex Receptacle, 125 V, 20 A:
1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
 2. Configuration: NEMA WD 6, Configuration 5-20R.
 3. Standards: Comply with UL 498.
 4. Marking: Listed and labeled as complying with NFPA 70, "Receptacles in Damp or Wet Locations" Article.
- D. Tamper- and Weather-Resistant Duplex Receptacles:
1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
 2. Configuration: NEMA WD 6, Configuration 5-20R.
 3. Standards: Comply with UL 498.
 4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

2.4 USB RECEPTACLES

A. USB Charging Receptacles

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell
 - b. Leviton
 - c. Pass & Seymour/Legrand
2. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap.
3. USB Receptacles: Dual USB Type A and USB Type C, 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. Available Products: Subject to compliance with requirements, products that may be incorporated into the work include, but are not limited to, the following:
 - a. Hubbell; GF20LA.
 - b. Pass & Seymour; 2095.

- c. Leviton; 7899.
 - 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: Non-feed through.
 - 5. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.
- B. Tamper-Resistant Duplex GFCI Receptacles, 125 V, 20 A:
- 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Hubbell; GFTR20.
 - b. Leviton; T7899.
 - c. Pass & Seymour; 2095TR.
 - 2. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. 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. Type: Non-feed through.
 - 5. Standards: Comply with UL 498, UL 943 Class A, and FS W-C-596.
 - 6. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" Article.
- C. Tamper- and Weather-Resistant, GFCI Duplex Receptacles, 125 V, 20 A:
- 1. Description: Integral GFCI with "Test" and "Reset" buttons and LED indicator light. Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
 - 2. Configuration: NEMA WD 6, Configuration 5-20R.
 - 3. Type: Non-feed through.
 - 4. Standards: Comply with UL 498 and UL 943 Class A.
 - 5. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.

2.6 TWIST-LOCKING RECEPTACLES

A. Twist-Lock, Single Receptacles, 120 V, 20 A

- 1. Hubbell; HBL2310.
- 2. Leviton; 2310.
- 3. Pass & Seymour; L520-R.
- 4. Configuration: NEMA WD 6, Configuration L5-20R.
- 5. Standards: Comply with UL 498.

B. Twist-Lock, Isolated-Ground, Single Receptacles, 125 V, 20 A:

- 1. Hubbell; IG2310.

2. Leviton; 2310-IG.
3. 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.
4. Configuration: NEMA WD 6, Configuration L5-20R.
5. Standards: Comply with UL 498.

2.7 PENDANT CORD-CONNECTOR DEVICES

- A. Matching, locking-type plug and receptacle body connector.
- B. Configuration: NEMA WD 6, Configurations L5-20P and L5-20R, and heavy-duty grade
- C. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.
- D. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.
- E. Standards: Comply with FS W-C-596.

2.8 TOGGLE SWITCHES, 120/277 V, 20 A

- A. Single-Pole Switches, 120/277 V, 20 A:
 1. Cooper; AH1221.
 2. Hubbell; HBL1221.
 3. Leviton; 1221-2.
 4. Pass & Seymour; CSB20AC1.
 5. Standards: Comply with UL 20 and FS W-S-896.
- B. Two-Pole Switches, 120/277 V, 20 A:
 1. Cooper; AH1222.
 2. Hubbell; HBL1222.
 3. Leviton; 1222-2.
 4. Pass & Seymour; CSB20AC2.
 5. Comply with UL 20 and FS W-S-896.
- C. Three-Way Switches, 120/277 V, 20 A:
 1. Hubbell; HBL1223
 2. Leviton; 1223-2
 3. Pass & Seymour; PS20AC3
 4. Comply with UL 20 and FS W-S-896.

D. Pilot-Light, Single-Pole Switches: 120/277 V, 20 A

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the work include, but are not limited to, the following:
 - a. Cooper; AH1221PL (120V and 277V)
 - b. Hubbell; HBL1221PL (120 V and 277 V).
 - c. Leviton; 1221-PLR (120 V) or 1221-7PLR (277 V).
 - d. Pass & Seymour; PS20AC1RPL (120 V) or PS20AC1RPL7 (277 V).
2. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."
3. Standards: Comply with UL 20 and FS W-S-896.

E. Lighted Single-Pole Switches, 120/277 V, 20 A

1. Description: Handle illuminated when switch is off.
2. Standards: Comply with NEMA WD 1, UL 20, and FS W-S-896.

F. Key-Operated, Single-Pole Switches, 120/277 V, 20 A:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the work include, but are not limited to, the following:
 - a. Hubbell; HBL1221L.
 - b. Leviton; 1221-2L.
 - c. Pass & Seymour; PS20AC1-L.
2. Description: Factory-supplied key in lieu of switch handle.
3. Standards: Comply with UL 20 and FS W-S-896.

2.9 DECORATOR-STYLE DEVICES

A. Decorator Duplex Receptacles, 125 V, 20 A

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the work include, but are not limited to, the following:
 - a. Hubbell; DR20.
 - b. Leviton; 16352.
 - c. Pass & Seymour; 26352.
2. Description: Two pole, three wire, and self-grounding. Square face.
3. Configuration: NEMA WD 6, Configuration 5-20R.
4. Standards: Comply with UL 498.

B. Decorator Tamper-Resistant Duplex Receptacles, 125 V, 20 A

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the work include, but are not limited to, the following:
 - a. Hubbell; DR20_TR.
 - b. Leviton; TDR20.
 - c. Pass & Seymour; TR26362.
 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.
- C. Decorator, Tamper- and Weather-Resistant, Duplex Receptacles, 125 V, 20 A:
1. Description: Two pole, three wire, and self-grounding. Integral shutters that operate only when a plug is inserted in the receptacle. Square face.
 2. Configuration: NEMA WD 6, Configuration 5-20R.
 3. Standards: Comply with UL 498.
 4. Marking: Listed and labeled as complying with NFPA 70, "Tamper-Resistant Receptacles" and "Receptacles in Damp or Wet Locations" articles.
- D. Decorator Single-Pole Switches, 120/277 V, 20 A:
1. Comply with UL 20.

2.10 WALL PLATES

A. General

1. Single Source: Obtain wall plates from same manufacturer of wiring devices.
2. Single and combination types shall match corresponding wiring devices.
 - a. Plate-Securing Screws: Metal with head color to match plate finish.

B. Metal Cover Plates

1. Material for Finished Spaces: Provide smooth, stainless steel plates, American Iron and Steel Institute (AISI) Type 302 stainless steel, 0.040" thick with satin smooth finish.
2. Material for Kitchens: stainless steel
3. Material for Unfinished Spaces: Galvanized steel
4. Provide removable plastic film to protect cover plates during installation. Remove film at time of final acceptance.
5. Use Hubbell #S Series or equal.

C. Damp and Wet-Location, Weatherproof Cover Plates

1. General

- a. Provide weatherproof cover plate for one GFI receptacle. Provide gasketed, spring loaded, vertically self-closing covers suitable for use in damp and wet locations as described in UL 514 and NEC.
 - b. Shall comply with NEMA 250 type 3R, unless otherwise noted on drawings.
 - c. Furnish base plates, covers, hinge pins, spring and screws with corrosion resistant type material.
 - d. Use Hubbell, die-cast aluminum cover #WP-26 series for GFCI receptacles or equal.
 - 2. While in use covers:
 - a. Provide weatherproof cover plate for one GFCI receptacle. Provide gasketed, spring loaded, vertically self-closing covers suitable for use in damp and wet locations while a plug is inserted into the receptacle as described in NEC.
 - b. Use Pass & Seymour clear cover #WIUC10 series for GFCI receptacles or equal.
- D. Material / Finish
- 1. AS SELECTED BY ARCHITECT, UNLESS OTHERWISE NOTED.
- 2.11 IDENTIFICATION FOR RECEPTACLES
- A. Nameplates: White P-Touch labels with black writing, indicating panel name and circuit number.
 - B. Device and faceplate colors:
 - 1. Emergency receptacles – red devices with a red faceplate.
 - 2. Receptacles fed from UPS A – gray device with gray faceplate.
 - 3. Receptacles fed from UPS B – black device with black faceplate.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B. Install blank cover plates on all outlet boxes in which no device is required or installed.
- C. Install devices with the vertical centerline plumb and with all edges of the device flush against the adjacent wall surfaces.
- D. Mount switches at 42" above finished floor unless otherwise noted.

- E. Ganged switches on 277-volt circuits shall have a barrier between each switch.
- F. Manual dimmers shall be installed in individual outlet boxes. Do not install in ganged boxes with other devices.
- G. De-rate ganged dimmer switches as instructed by manufacturer. Do not use common neutrals in dimmer circuits.
- H. Mount receptacles vertically with the centerline 18" above finished floor and with grounding slot at bottom.
- I. Mount GFCI receptacles above counters in bathrooms and at counters within 6'-0" of sinks, whether indicated as GFCI type or not.
- J. Cover plates on pressed steel outlet boxes in furred areas, attics, etc., or exposed in mechanical equipment rooms shall be of the same material as the outlet box.
- K. Cover plates in locations concealed from public view shall have the circuit numbers and source feed point hand labeled with marking black pen (permanent marker). See Section 26 05 53 "Identification for Electrical Systems" for labeling.
- L. All low voltage wiring for controls, occupancy sensors, etc., shall be in conduit.
- M. Provide labeling for all lock switches, pilot switches, switches from which equipment or circuit controlled cannot be readily seen, three or more switches under a common plate and for switches as indicated.
- N. Provide cover plates for all outlet boxes, switches, receptacles, etc.
- O. 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.
- P. 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. Pigtail existing conductors is permitted, provided the outlet box is large enough.

Q. 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 (152 mm) 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.

R. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right .

S. 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.

T. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan-speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device, listing conditions in the written instructions.

U. 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.

V. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

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 26 05 53 "Identification for Electrical Systems."
- B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-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:
 - 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. Wiring device will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION

SECTION 26 28 13

FUSES

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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. Cartridge fuses rated 600 V ac and less for use in the following:
 - a. Control circuits.
 - b. Motor-control centers.
 - c. Switchboards.
 - d. Enclosed controllers.
 - e. Enclosed switches.
2. Spare-fuse cabinets.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
 - a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
 - b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
 2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
 3. Current-limitation curves for fuses with current-limiting characteristics.
 4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.

Submit in electronic format suitable for use in coordination software and in PDF format.

5. Coordination schedule includes; equipment tag, fuse size, fuse type. short circuit rating, panel fed from, circuit number, drawing single line, drawing floor plan.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 011000 "General Requirements" include the following:

1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in electronic format suitable for use in coordination software and in PDF format.
4. Coordination charts and tables and related data.

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. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type, 100 amps and above, and not less than four of each size and type for below 100 amps.

1.6 FIELD CONDITIONS

- A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Bussmann, an Eaton business.
2. Littelfuse, Inc.
3. Ferraz Shawmut, Inc.
4. Edison Fuse, Inc.

- B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
 - 1. Type RK-1: [250] [600]-V, zero- to 600-A rating, 200 kAIC, time delay.
 - 2. Type RK-5: [250] [600]-V, zero- to 600-A rating, 200 kAIC, time delay.
 - 3. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, time delay.
 - 4. Type CD: 600-V, 31- to 60-A rating, 200 kAIC, time delay.
 - 5. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
 - 6. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.
- 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 NEMA FU 1 for cartridge fuses.
- D. Comply with NFPA 70.
- E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.3 SPARE-FUSE CABINET

- A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
 - 1. Size: Adequate for storage of spare fuses specified with 20 percent spare capacity minimum.
 - 2. Finish: Gray, baked enamel.
 - 3. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.
 - 4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

- 1. Service Entrance: Class L, or Class RK1.
- 2. Feeders: Class L, Class RK1 or Class RK5.
- 3. Motor Branch Circuits: Class RK1 or Class RK5.
- 4. Large Motor Branch (601-4000 A): Class L, time delay.
- 5. Other Branch Circuits: Class RK1 Class RK5 or Class J.
- 6. Control Transformer Circuits: Class CC, time delay, control transformer duty.
- 7. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.3 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
- B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Owner's representative.

3.4 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION

SECTION 26 28 16

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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. Nonfusible 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. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
 5. 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.
- B. Provide matrix for enclosed switches and circuit breakers to include the following: equipment name, over current protective device type, rated voltage, current, short circuit rating Fed-From, Circuit #, Number of Phases, including neutral and ground kit, enclosure type, drawing #, room number, manufacturer, selected options, and fuse kit.
- C. 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. Field quality-control reports.
1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- C. Manufacturer's field service report.

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 011000 "Summary," 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.

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 percent of quantity installed for each size and type, but no fewer than two of each size and type, 100 amps and above, and not less than four of each size and type for below 100 amps.

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 (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
 2. Altitude: Not exceeding 6600 feet (2010 m).

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 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.
- E. ANSI/ASME A17.1

2.2 FUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Cutler Hammer.
 2. Square D; by Schneider Electric.
 3. ABB/General Electric.
- B. Type HD, Heavy Duty:
1. Single throw.
 2. Three pole.
 3. 600-V ac.
 4. 1200 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, where indicated on drawings. Contact rating 24-V dc.
 6. Hookstick Handle: Allows use of a hookstick to operate the handle.
 7. Lugs: Mechanical type, suitable for number, size, and conductor material.
 8. Service-Rated Switches: Labeled for use as service equipment.

2.3 NONFUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Cutler Hammer.
 2. Square D; by Schneider Electric.
 3. ABB/General Electric.
- B. Type GD, General Duty, Three Pole, Single Throw, 240-V ac, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

- C. 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.
- D. 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 dc.
 - 6. Hookstick Handle: Allows use of a hookstick to operate the handle.
 - 7. Lugs: Mechanical type, suitable for number, size, and conductor material.
 - 8. Service-Rated Switches: Labeled for use as service equipment.

2.4 MOLDED-CASE CIRCUIT BREAKERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Cutler Hammer.
 - 2. Square D; by Schneider Electric.
 - 3. ABB/General Electric.
- 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.
- E. MCCBs shall be equipped with a device for locking in the isolated position.
- F. Lugs shall be suitable for Lugs shall be suitable for rated wire, sized according to the 167 deg F (75 deg C) temperature rating in NFPA 70.

- 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. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.
- L. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.
- M. Ground-Fault Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
- N. Ground-Fault Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).
- O. Features and Accessories:
 - 1. Standard frame sizes, trip ratings, and number of poles.
 - 2. Lugs: Mechanical or 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; 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.
 - 7. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.

8. Alarm Switch: One NO NC contact that operates only when circuit breaker has tripped.
9. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
10. Electrical Operator: Provide remote control for on, off, and reset operations.
11. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.5 MOLDED-CASE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Eaton Cutler Hammer.
 2. Square D; by Schneider Electric.
 3. ABB/General Electric.
- B. Description: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.
- C. Standard: Comply with UL 489 with interrupting capacity to comply with available fault currents.
- D. Features and Accessories:
 1. Standard frame sizes and number of poles.
 2. Lugs:
 - a. Mechanical or Compression type, suitable for number, size, trip ratings, and conductor material.
 - b. Lugs shall be suitable for rated wire sized according to the 167 deg F (75 deg C) temperature rating in NFPA 70.
 3. Ground-Fault Protection: Comply with UL 1053; 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.
 4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
 5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 6. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
 7. Alarm Switch: One NO NC contact that operates only when switch has tripped.
 8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
 9. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
 10. Electrical Operator: Provide remote control for on, off, and reset operations.
 11. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

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), gray baked enamel paint, electrodeposited on cleaned, phosphatized galvanized steel (NEMA 250 Types 3R, 12), a brush finish on Type 304 stainless steel (NEMA 250 Type 4-4X stainless steel).
- 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 (NEMA 250 Type 1), directly operable through the dead front trim of the enclosure (NEMA 250 Type 3R). 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.
- E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.
- F. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

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.
- 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 Owner no fewer than fourteen 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.
- D. Comply with NFPA 70E.

3.2 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. Outdoor Corrosive Locations: Type 4X
 4. Kitchen Areas: NEMA 250, Type 4X, stainless steel
 5. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
 6. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

3.3 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. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install fuses in fusible devices.
- E. Comply with NFPA 70 and NECA 1.

3.4 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 lamicoid nameplate.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. 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 fuseholder. 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."

C. 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 in approved Coordination Study. 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 in approved Coordination Study. 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 in approved Coordination Study. 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 in approved Coordination Study 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 in approved Coordination Study 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:
 - 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.

- 5. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- E. 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.

3.6 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 "Overcurrent Protective Device Coordination Study and Arc Flash Hazard Analysis"

END OF SECTION

SECTION 26 31 20

PHOTOVOLTAIC SYSTEM

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY OF WORK

- A. The photovoltaic (PV) System described in this Section is a delegated design. The work herein is the responsibility of the PV System Design/Build Contractor (herein referred to as Contractor). See Section 01 13 00 – Delegated Design Requirements for additional requirements.
- B. This section provides requirements for design, fabrication, supply, and delivery for solar-based electrical generating systems.

1.2 GENERAL PROVISIONS

- A. All the Contract Documents, including General and Supplementary Conditions and Division 1 Specification Sections, apply to the work of this Section.
- B. Examine all Drawings and all other Sections of the Specifications for requirements which affect the work of 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.

1.3 RELATED WORK

- A. Division 07 – Coordination with roof construction for attachment system
- B. Section 26 00 01 - Electrical Work
- C. Section 26 05 19 – Low Voltage Electrical Power Wiring and Cable
- D. Section 26 05 26 – Grounding and Bonding for Electrical Systems
- E. Section 26 05 33 – Raceway and Boxes for Electrical Systems
- F. Section 26 05 48 – Seismic Controls for Electrical Systems
- G. Section 26 05 53 – Identification for Electrical Systems
- H. Section 26 05 00 – Common Work Results for Electrical
- I. Section 26 24 16 – Panelboards
- J. Section 26 05 73 – Overcurrent Protective Device Coordination Study and Arc Flash Analysis
- K. Section 26 41 13 – Lightning Protection for Structures
- L. Section 27 15 00 – Communications Horizontal Cabling

1.4 REFERENCES

- A. Design and installation of the PV system shall conform, at minimum, to the following Standards:
 - 1. IEEE 1547 Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces
 - 2. IEEE 80 Recommended Grounding Practices
 - 3. IEC-61-215
 - 4. UL-1741 Standard for Safety for Static Inverters and Charge Controllers for Use in Photovoltaic Power Systems.
 - 5. UL-1703 Standard for Flat-Plate Photovoltaic Modules & Panels.
 - 6. ANSI/NFPA 70 National Electrical Code (NEC) - 2023
 - 7. NFPA 1, Fire Code – 2021
 - 8. International Building Code (IBC) – 2021
- B. All products shall be UL listed.
- C. Additional Standards:
 - 1. All local codes and all local authorities having jurisdiction. Codes include, but are not limited to:
 - a. Massachusetts State Building Code, 780 CMR, 10th Edition (International Building Code, 2021 Edition, as amended)
 - b. Massachusetts Comprehensive Fire Safety Code, 527 CMR 1.00 (NFPA 1, 2021 Edition, as amended by 527 CMR Chapter 1)
 - c. Massachusetts Electrical Code (NFPA 70, 2023 Edition, as amended by 527 CMR Chapter 12)
 - d. City of Worcester current Ordinances & Regulations
 - 2. National Grid Massachusetts (National Grid MA) utility grid interconnection requirements.
 - 3. Applicable referenced standards in related sections.

1.5 DESCRIPTION OF WORK

- A. Contractor shall provide complete design, provision, installation, commissioning, and testing for a new Panel Photovoltaic (PV), grid-tied, structurally mounted system, as described herein.
- B. All work shall comply with these specifications, manufacturer's instructions, all applicable codes and standards, National Grid Massachusetts electric utility rules, and all local authorities having jurisdiction.
- C. System electrical design by State of Massachusetts licensed Electrical Engineer. Provide plan layout, equipment elevations, wiring diagrams, calculations, and equipment identification for the selected equipment. Provided design drawings are intended to demonstrate the typical installation expected for the basis of design equipment, with final design to be provided by the installer for the equipment selected and approved for installation.

- D. The design documentation shall include, but not be limited to, design drawings showing PV module layout, all AC and DC wiring associated with the system, conduit layout, details of equipment layout, equipment selection, and specifications. The equipment includes, but is not limited to, PV modules, inverters, disconnects, wire, conduit, junction boxes, and any other needed equipment. See Division 07 for roof mounting attachment system requirements.
- E. Submit for plan review and obtain a permit from Labor and Industries and any other necessary permits not covered in the general building permit required to perform the work detailed on the Drawings and specified herein. PV vendor to submit for and obtain all relevant permits required for installation and energization of the PV system.
- F. Provide all material, tools, labor, and equipment necessary for complete installation of the PV system up to point of connection, as shown on the Drawings. Verify and coordinate circuit breaker disconnect size with the Electrical Contractor.
- G. Provide access to equipment for maintenance and service as required by the manufacturer's instructions and applicable codes.
- H. The Drawings show general equipment locations and sizes for the major PV system equipment. The Contractor shall comply with these criteria and include them in the design. Any deviations from the criteria described in this specification or the Drawings must receive written approval by the Architect and Engineer. Any work that is described as 'by others', that is affected by these deviations becomes the responsibility of the Contractor and shall not result in an increase in project cost.
- I. Contractor shall coordinate with the Architect on the locations and appearance of all exposed equipment, including PV modules, mounting structure, conduit, wireways, and junction boxes. All locations must be approved by the Architect prior to installation.
- J. Contractor shall coordinate with all trades needed for a complete installation including all required controls, electrical services, and clearances.
- K. Provide permanent plaque at the main medium-voltage switchgear identifying that there are multiple power sources. Signage shall comply with NEC Art. 705.10.
- L. Utility Approval and Incentive Programs
 - 1. Work directly with National Grid MA to provide all required paperwork and forms to apply for interconnection with the utility grid.
 - 2. Coordinate required reviews and inspections with National Grid MA.
 - 3. Advise the Owner of any other incentive or rebate programs that they may qualify for at the time of system installation. Contractor is responsible for working with the Architect and Owner to obtain the maximum available rebate through any and all available rebate program and is responsible for complying with all applicable requirements of those programs and is responsible for completing all documentation required to obtain the rebate(s).

1.6 COORDINATION WITH OTHER SECTIONS

- A. As part of this scope of work, Contractor shall coordinate with Section 26 24 13 - Switchboards and Section 26 28 16 - Enclosed Switches and Circuit Breakers and

provide input on the rating and quantity of 480V circuit breakers which will need to be provided at the AC Combiner Switchboard.

- B. Contractor shall provide a utility and code-compliant grounding system in coordination with Section 26 05 26 – Grounding and Bonding for Electrical Systems. Contractor shall coordinate with Section 25 05 73 – Overcurrent Protective Device Coordination Study and Arc Flash Analysis to provide PV system information to input into this study and coordinate with the results of the study for the design of the grounding system. See the single line in the Drawings for additional information.

1.7 SYSTEM OPERATION

- A. When sunlight is available, the PV modules convert sunlight into electricity. When grid (utility) power is present, the solar power output is used to run AC electrical loads on site and sell any excess power to the grid (in this order of priority).
- B. The PV system operates in parallel with the grid. If the electrical demand on site is less than the solar output, the excess solar output will be exported to the grid. If the electrical demand on site is more than the solar output, the grid will supply the balance of power needed.
- C. If the utility grid fails, the solar output also ceases. No power is available until grid power returns. A battery energy storage system is not provided as part of this system.
- D. When utility power returns, the system automatically switches back to normal grid-tied mode and solar power resumes.

1.8 SYSTEM DESIGN CRITERIA

- A. PV system shall include PV Modules in a layout that maximizes the generation capacity within the allowed roof area, preliminary layout is shown on the PV Drawing.
- B. Each series string of PV modules shall be independently protected by an isolation fuse or breaker before it is connected in parallel with the other strings on that PV output circuit. All conductors and overcurrent devices shall be sized per the requirements of NEC Art. 690.8 and 690.9.
- C. Contractor shall measure shading effects from nearby objects and use this information to determine optimum grouping of series strings. Strings shall be grouped so that major shaded areas cover the least number of groups possible. Engineering approval is required on final stringing plan.
- D. All roof wiring shall be run in conduit or wireway.
- E. All roof wiring, raceway, and junction boxes shall be hidden from view beneath the modules.
- F. All DC conductors shall be sized such that there is a maximum of 2% voltage drop measured at the short circuit current rating of that circuit over the entire length of each circuit from PV module to inverter and back to PV module. All AC conductors shall be sized for a maximum of 2% voltage drop measured at the continuous AC current rating of the inverter between the inverter and the point of interconnection at the AC Combiner Switchboard.

- G. PV array shall be provided with NEC 690.12 rapid shut down system, unless confirmed that one is not required per code or utility requirements. Expected is modules for PV panel connection, and a transmitter to signal modules to shut down upon loss of grid power. An NEC compliant product providing the required functionality shall be submitted for review during the construction administration project phase. Other products providing the required functionality will be reviewed for approval without substitution request.

1.9 DESIGN CONSIDERATIONS

- A. Ensure PV system mounting type (ballasted, rail, etc.) is coordinated with project structural engineer and architect at all building interfaces, as applicable. PV system shall conform to structural design criteria, including max point loading and max system loading for the roof structure, as detailed on structural drawing S11-03.
- B. Installation of the PV system shall minimize all internal roof curbs, mechanical equipment, and other roof obstructions to ensure proper PV system securement in all cases, as applicable.
- C. Ensure that the PV array layout provides allowances for all roof penetrations and roof drains, as applicable.
- D. Ensure that the PV array layout allows for sufficient access from the roof perimeter on all sides, as applicable.
- E. Ensure that the PV array layout allows for sufficient clearances as specified NFPA-1 or applicable local fire code, as applicable.

1.10 SUBMITTALS

- A. Submit materials and product data in accordance with of Section 01 33 00 – Submittal Procedures. Furnish manufacturers' technical literature, standard details, product specifications, and installation instructions for all products.
- B. Shop Drawings
 - 1. Complete, scaled shop drawings showing the PV system layout on the roof with dimensions and heights of all roof penetrations, roof drains, and equipment within an area that includes the array and the area to the roof perimeter around the entire array. Shop drawings should include all components and accessories and planned roof penetrations being provided or required for operation as specified in this Section.
 - 2. PV structure/support drawings prepared and stamped by a Structural engineer licensed in the state of Massachusetts. Drawings shall detail the proper support, seismic bracing, and other structural elements of the installation.
 - 3. Weight of system in lbs/sqft and point loading in lbs for Structural Engineer review.
 - 4. Single line electrical diagram showing all DC and AC wiring and related electrical equipment in the PV system. Clearly show and differentiate between factory and field wiring.
 - 5. An equipment layout drawing showing location of all PV equipment and conduit runs.

6. Details describing the PV module roof mounting system.

- C. Product Data: Provide technical specifications of all PV system components, including but not limited to PV modules, inverters, disconnects, and combiner boxes.
- D. Submit a letter of approval from the PV system manufacturer that acknowledges the system's ability to meet the local standards for wind design speeds for the particular application. If requested, submit written documentation from an independent testing agency that demonstrates that the system meets the local standards for wind design speeds for the particular application.

1.11 QUALITY ASSURANCE

- A. In accordance with Section 01 40 00 – Quality Requirements.
- B. All material supplied for this project shall be new.
- C. Contractor shall be a licensed solar contractor with minimum of three years of experience. The installation crew is to have a minimum of one licensed electrician who has documented experience with installing utility interconnected photovoltaic systems.
- D. The manufacturer of any PV modules in the project shall be a company specializing in the manufacture of PV modules and have at least 10 years of documented experience with their hardware in commercial applications in the field.
- E. Balance of System equipment suppliers shall provide local representation when requested and shall have been actively engaged in the assembly, installation, and service of this equipment for a period of not less than 3 years.
- F. Equipment suppliers shall have full parts backup and service availability for this equipment.
- G. The Contractor shall be approved for installation of the PV system by the system providers.

1.12 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, and protect products under provisions of Section 01 60 00 – Product Requirements.
- B. Receive all PV materials required for the work. Store and handle all materials to comply with manufacturer's directions and as required to prevent damage.
- C. Protect all PV materials during delivery, storage, and handling to comply with manufacturer's directions and as required to prevent damage to PV materials and balance of system component electronics.
- D. Replace any scratched or damaged PV materials or system components.

1.13 CLOSEOUT SUBMITTALS

- A. Submit items listed below in accordance with the provisions of Section 01 77 00 – Closeout Procedures.
- B. Project As-Built Documents:

1. Submit in accordance with Section 01 78 39 – Project Record Documents.
 2. Document as-built locations of all PV panels, DC-AC inverters, switches, interconnection locations, and associated conduit runs.
 3. Submit accurate as-built drawings to the Owner after construction is complete.
- C. Operation and Maintenance Data:
1. Submit in accordance with Section 01 78 23 – Operation and Maintenance Data.
 2. Provide complete operation and maintenance manuals for the PV system.
 3. The complete manual shall provide operating and maintenance instructions for the system as a whole, performance curves, a copy of the required submittals, product cut sheets, recommended and complete parts lists, wiring diagrams, maintenance schedules and procedures, troubleshooting procedures, a copy of all start-up tests described in Part 3, a copy of the photo record, and a copy of the written Owner acceptance letter and written Utility approval of the system.
- D. Provide a copy of product warranties and supplier and installer contact information.
- 1.14 SPARE PARTS
- A. Furnish greater than 1% of PV modules to the Owner as attic stock.
- 1.15 WARRANTY
- A. Conform to the requirements of “Warranties” as stated in Section 01 60 00 – Product Requirements.
- B. PV system output shall be guaranteed based on the contractor’s final design. Contractor shall test and verify PV output matches contractor final design drawings upon completion of the PV system installation.
- C. Provide the Owner with a full 1-year warranty on the PV systems installed. The warranty shall provide for service at the site including troubleshooting, repair, labor, and replacement of components found to be defective. This warranty will start upon written acceptance of the PV systems by the Owner. This warranty will not be deemed to have begun until 30 continuous days of trouble-free operation of the PV systems are achieved.
- D. PV modules shall carry a minimum manufacturer’s warranty of 25-year, that shall be transferred to the Owner upon project acceptance. Annual degradation rate not exceeding 0.5%.
- E. Inverters shall carry a minimum manufacturer’s warranty of 12-year, that shall be transferred to the Owner upon project acceptance.
- F. Any other supplied materials not included in the above materials shall be provided with the manufacturer’s standard warranty.
- G. Submit project warranties at the end of construction as required by Section 01 77 00 – Closeout Procedures.

PART 2 - PRODUCTS

2.1 COMPONENTS

A. PV Module:

1. PV modules shall be listed to UL 1703 and compliant with IEEE 1547.
2. Basis of Design Manufacturer:
 - a. Vertex TSM-DE18M (II) – 500Wp, or approved equal.
3. Other Manufacturers:
 - a. Jinko, Q-Cells, Hanwha, or approved equal.

B. Bypass Diodes: PV modules shall be supplied with factory installed by-pass diodes. One by-pass diode is recommended for each set of 18 series cells. Other configurations will be considered if certified by the module manufacturer.

C. DC-AC Inverters:

1. Basis of Design Manufacturer:
 - a. Sunny Tri power CORE1-US, or approved equal.
2. Other Manufacturers:
 - a. Sungrow, Huawei, Enphase Energy, or approved equal
3. Modular inverter system compatible with its associated PV system array output.
4. Integral DC disconnect.
5. Inverters shall be capable of complete automatic unattended operation including start-up, synchronization and disconnect, and operating in parallel with other inverters and the utility.
6. Inverters shall be listed to UL1741 and compliant with IEEE 1547.

D. Wire: UL Listed, new, copper, and of the correct type and continuous for each wiring run. Insulation shall have an appropriate rating per the application. The following additional requirements apply:

1. In areas where the conductors may be subjected to high temperatures, such as in conduits exposed on the roof, the insulation rating shall be rated 90°C. Other areas shall use insulation rated for a minimum of 75°C.
2. Any wire that is exposed to sunlight shall be UL recognized as sunlight resistant and labeled as such.
3. Conductors #10AWG and larger shall be stranded.
4. Conductor splices and terminations must be UL listed.

PART 3 - EXECUTION

3.1 GENERAL

- #### **A.**
- Instruct any subcontractors required for the installation in the correct installation and wiring of the entire PV system. The installation is to be in full compliance with the PV system components manufacturer's instructions and as required for a neat,

workmanlike and fully operational PV system. Ensure that all required and recommended clearances and other code requirements are maintained.

- B. All PV modules shall be field-tested prior to installation to verify electrical integrity and specified performance per the manufacturer's recommendations. Each module shall be tested for open circuit voltage (Voc) and short circuit current (Isc) after ten minutes of sunlight exposure under clear weather conditions and the results shall be compared with values provided by the module manufacturer. The module manufacturer shall provide module testing instructions and tables of expected values for measurement of individual module Voc and Isc. Follow the instructions and refer to these tables when testing the PV modules. Ambient temperature and solar irradiance in the plane of the array are to be measured and recorded. The module measurements are to be recorded and compared to the values in the tables. In the event the measurements are out of the expected ranges in the table, the module shall be deemed defective and a replacement from the manufacturer should be obtained. A copy of all of the measurements that are taken is to be provided to the Owner after testing and included in the Operation and Maintenance Manual as described in Part 1.
- C. Prior to installing the PV array(s), clean the roof of any debris or dirt and inspect the roof to ensure that the installation is complete.
- D. All building penetrations shall be sealed and protected.
- E. Installed PV modules are to be visually uniform and shall be subject to visual inspection for consistency. Replacement of unacceptable PV modules is the responsibility of the Contractor.
- F. PV system interconnection shall comply with NEC Art. 705 requirements and with National Grid MA requirements.

3.2 LABELING

- A. Label all source circuits (positive and negative wires) within all boxes for all systems for polarity and string number, white is the accepted color-coding for negative conductors of a photovoltaic system installed in North America.
- B. Label all outdoor equipment with type NP nameplate. Lettering shall be standard engraver's letter style using a standard size appropriate for the application in accordance with the NEC.
- C. Label each DC disconnect with operating dc current (Imax), system operating dc voltage (Vmax), maximum string dc voltage (Voc), and maximum system dc current (Isc).
- D. The main breaker at the AC Combiner Switchboard shall be labeled in accordance with NEC Art. 690.13:

**PV SYSTEM DISCONNECT
480V, MAX CURRENT: [MAX AC OPERATING CURRENT]**

**WARNING
ELECTRIC SHOCK HAZARD. TERMINALS ON THE LINE AND LOAD SIDES MAY BE
ENERGIZED IN THE OPEN POSITION.**

3.3 CLEANING

- A. Remove all excess sealants, filings, grease, tape residue, dust, and debris from all PV system components.
- B. Work shall be protected from damage from other trades.
- C. Ensure the site is clean and secure, in a workman like condition, all during and at the completion of the project.

3.4 INSPECTIONS AND START-UP

- A. General
 - 1. The PV systems are not accepted until the Owner provides a written statement of acceptance.
 - 2. The Contractor shall notify the Architect a minimum of 5 days before closing in of to-be-concealed work so that an Owner's representative may inspect the work.
- B. Inspections
 - 1. Before starting or operating the system, Contractor shall:
 - a. Check continuity of all conductors and grounding conductors to verify that there are no faults, and that all equipment has been properly installed.
 - b. Verify that all non-current-carrying metal parts are solidly grounded, and all equipment and PV system grounding is installed and functional per NEC 250.
 - c. Inspect that all outdoor components are weatherproof and capable of surviving intact under the site environmental conditions. Check that all outdoor enclosures are equipped to alleviate condensation. Check that all covers and cable exits are gasketed or otherwise designed to limit the entrance of dirt and moisture.
 - d. Obtain a final inspection approval from Labor and Industries, final inspection approval from National Grid MA, and any other involved AHJ. Contractor shall be present on site for these inspections.
- C. Start-up and Testing
 - 1. Ensure that there is written permission from the utility for interconnection of the PV system. (Note: Utility may require that a representative of the utility be on-site during initial interconnection. Contractor must accommodate this requirement, if stated by the utility).
 - 2. Once final approvals have been received, Contractor shall test all equipment to ensure specified capacity and performance of the system. The Contractor shall notify the Architect a minimum of 5 days prior to the test so that an Owner's representative may witness the test. Contractor shall replace or revise any equipment, systems, or work found deficient during the test.
 - 3. Perform all tests required by the Manufacturer as outlined in the inverter Installation and Operation Manual.
 - 4. Contractor shall make final adjustments to all inverters so that they will be placed in an acceptable operating condition. Adjustable parameters shall be set

so that the PV system will produce the maximum possible amount of energy on an annual basis.

5. Additional testing shall demonstrate proper functional operation of control and protective features under normal and abnormal conditions. In some cases, devices external to inverters can handle one or more of these features.
 - a. Confirm Wake-Up and Sleep Separations.
 - b. Check loss of utility and loss of array.
6. Turn on the PV systems and verify that the PV systems are working as specified. After manual start-up, witness and record proper system operation under automatic start-up, full power operation and automatic nighttime shutdown. Record all operating parameters of the PV systems during this period.
7. Include a copy of the start-up test report in the Operation and Maintenance Manual defined in Part 1.

D. Leave the system in operating condition.

3.5 TRAINING

- A. Provide a job site training session and long-term technical support (1 yr.) for the Owner's designated maintenance personnel.

3.6 COMMISSIONING

- A. Refer to Sections 01 91 13 General Commissioning Requirements and 26 05 00 – Common Work Results for Electrical for requirements.

END OF SECTION

SECTION 26 32 13

DIESEL EMERGENCY ENGINE GENERATORS

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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 includes packaged engine-generator set for NFPA-110 Level 1 emergency power supply with the following features:
 - 1. Diesel engine/generator set.
 - 2. Unit-mounted cooling system.
 - 3. Unit-mounted control and monitoring.
 - 4. Performance requirements for sensitive loads.
 - 5. Free Standing load bank.
 - 6. Outdoor sound attenuated weather protective factory skin-tight enclosure.
- B. Related Sections include the following:
 - 1. Section 263600 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.
 - 2. Section 262416 "Panelboards" for enclosure integrated panelboard.

1.3 DEFINITIONS:

- A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of packaged engine generator indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. In addition, include the following:

1. Thermal damage curve for generator.
 2. Time-current characteristic curves for generator protective device.
- B. 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. Dimensioned outline plan and elevation drawings of engine-generator, enclosure, and other components specified.
 2. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 3. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.
 4. Wiring Diagrams: Power, signal, and control wiring.
- C. Performance Calculations: Provide manufacturer's calculation for engine and alternator sizing based on actual loads to be served. Calculation shall clearly show that the engine/generator set meets the performance requirements indicated. Contractor shall provide information on motor starting characteristics for actual products submitted by the mechanical contractor.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For manufacturer, and testing agency.
- B. Source quality-control test reports.
1. Certified summary of prototype-unit test report.
 2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
 3. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
 4. Report of sound generation.
 5. Report of exhaust emissions showing compliance with applicable regulations.
 6. Certified Torsional Vibration Compatibility: Comply with NFPA 110.
- C. Field quality-control test reports.
- D. Warranty: Special warranty specified in this Section.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
1. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.

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. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
 - 2. Filters: One set each of lubricating oil, fuel, and combustion-air filters.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
 - 1. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site. All service technicians shall be factory certified, and have been trained and certified NFPA 101 Life Safety and OSHA 10 Card
 - 2. Engineering Responsibility: Preparation of data for vibration isolators and seismic restraints of engine skid mounts, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL), and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- C. Source Limitations: Obtain packaged generator sets and auxiliary components through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with ASME B15.1.
- F. Comply with NFPA 37.
- G. Comply with NFPA 70.
- H. Comply with NFPA 110 requirements for Level 1 emergency power supply system.
- I. Comply with UL 2200.
- J. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

- K. Noise Emission: Comply with applicable state and local government requirements, but as a minimum, the resultant sound level of the generator and enclosure, shall not noise level as indicated in Section 2.9 Q. Noise Criteria.

1.9 PROJECT CONDITIONS

- A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 - 1. Ambient Temperature: Minus 15 to plus 40 deg C. Relative Humidity: 0 to 95 percent.
 - 2. Altitude: Sea level to 1000 feet (300 m).

1.10 COORDINATION

- A. Coordinate size and location of concrete bases for package engine generators. SteelCast Steel support angles into concrete base to ensure level mounting. Ensure steel beams are level prior to installation. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.11 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components including load bank and enclosure that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: 5 years from date of Substantial Completion.
 - a. There shall be no deductible cost to the owner or any warranty registration fees.
 - b. The warranty shall include all costs associated with providing and installing a temporary generator set should a repair take longer than 48 hours. A rigging allowance shall also be included and documented in the factory warranty statement should it become necessary to remove the unit from the site for repair due to a catastrophic failure.

1.12 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment. Engine fluid sampling and analysis shall also be included annually. Provide option to extend the maintenance contract for a period of 5 years after the expiration of the initial maintenance agreement.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Caterpillar, Inc.
 2. Cummins Inc.
 3. Rehlko (Kohler Energy)
 4. Generac Power Systems

2.2 ENGINE-GENERATOR SET

- A. Factory-assembled and -tested, engine-generator set.
- B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
- C. Capacities and Characteristics:
1. Power Output Ratings: Nominal ratings as indicated on drawings
 2. Output Connections: Three-phase, four wire.
 3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- D. Generator-Set Performance for Sensitive Loads:
1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance provided that it does not exceed DOE motor rating requirements.
 - a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
 2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
 3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
 4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
 5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
 6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.

7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
 - a. Provide permanent magnet excitation for power source to voltage regulator.
10. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.3 ENGINE

- A. Fuel: Fuel oil. Ultra Low Sulfur Diesel (ULSD)
- B. Rated Engine Speed: 1800 rpm.
- C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).
- D. Lubrication System: The following items are mounted on engine or skid:
 1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
 2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
 3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- E. Engine Fuel System:
 1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
 2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
- F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity. Provide isolation valves.
- G. Governor: Product of the engine manufacturer, adjustable electronic isochronous, with speed sensing.
- H. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
 1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.

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3. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
 4. The radiator shall carry an ambient rating of 120 degrees F based on a seven degree temperature rise across the engine, and shall be based on a maximum of a .5" of WC static pressure on the radiator face.
 5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
 - a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and noncollapsible under vacuum.
 - b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- I. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
1. Minimum sound attenuation of 25 dB at 500 Hz, but may be higher as required to meet overall sound criteria as indicated in section 2.9.
 2. Sound level measured at a distance of 50 feet (3 m) from exhaust discharge in any horizontal direction after installation is complete shall be 70 dBA or less.
 3. The silencer shall be internally mounted and insulated inside the enclosure and shall include a condensation drain that is piped to the side wall of the enclosure with a manual maintenance valve for periodic draining. The valve shall be located in an easily accessible location within the enclosure.
- J. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- K. Starting System: 24-V electric, with negative ground.
1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
 2. Cranking Motor: Dual heavy-duty units that automatically engage and release from engine flywheel without binding.
 3. Cranking Cycle: As required by NFPA 110 for system level specified.
 4. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least three times without recharging.
 5. Battery Cable: Size as recommended by engine manufacturer based on battery location within enclosure. Include required interconnecting conductors and connection accessories.
 6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.
 7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
 8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236 and include the following features:

- a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
- b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
- c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
- d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
- e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
- f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.4 FUEL OIL STORAGE

- A. Comply with all Federal and State regulations.
- B. Comply with NFPA 30.
- C. Piping: Fuel-oil piping shall be Schedule 40 black steel, complying with requirements in Section 23 11 13 "Facility Fuel-Oil Piping." Cast iron, aluminum, copper, and galvanized steel shall not be used in the fuel-oil system.
- D. Main Fuel Pump: Mounted on engine to provide primary fuel flow under starting and load conditions.
- E. Fuel Filtering: Provide all-in-one, high performance, fuel/water separator designed for common rail fuel system. Filter shall be mounted between the supply line of the fuel tank and the diesel engine, with minimum efficiency of 99.9% at 7 microns. Fuel filter shall have a fuel clog level indicator and a Water-In-Fuel (WIF) sensor. The performance of the fuel filter shall meet or exceed this efficiency and be suitable for the engine manufacturer's requirements.
- F. Subbase-Mounted, Double-Wall, Day Tank: Factory installed and piped, complying with UL 142 fuel-oil tank. Features include the following:
 - 1. Reverse fuel pump to be included.
 - 2. Runtime: minimum of 8 hours while operating at full load
 - 3. Tank level indicator: mechanical gauge
 - 4. Leak detection in interstitial space.
 - 5. Low fuel alarm

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6. High fuel alarm
7. Containment Provisions: Comply with requirements of authorities having jurisdiction.

2.5 CONTROL AND MONITORING

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down generator set.
- B. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration. A remote panel shall also be provided as indicated on the drawings to provide remote monitoring/annunciation of all systems.
- C. Local Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 1 system, and the following:
 1. AC voltmeter.
 2. AC ammeter.
 3. AC frequency meter.
 4. DC voltmeter (alternator battery charging).
 5. Engine-coolant temperature gage.
 6. Engine lubricating-oil pressure gage.
 7. Running-time meter (non-resetting type).
 8. Ammeter-voltmeter, phase-selector switch(es).
 9. Generator-voltage adjusting rheostat.
 10. Start-stop switch.
 11. Overspeed shutdown device.
 12. Coolant high-temperature shutdown device.
 13. Coolant low-level shutdown device.
 14. Oil low-pressure shutdown device.
 15. Fuel tank derangement alarm.
 16. Fuel tank high-level shutdown of fuel supply alarm.
- D. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.
- E. Provide dedicated customer use RS-485 modbus RTU communications port. Provide all data converters as necessary to facilitate communication between generator and BAS system. Provide access to the following information to the BAS system:
 1. Overcrank shutdown.
 2. Coolant low-temperature alarm.
 3. Control switch not in auto position.

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4. Battery-charger malfunction alarm.
5. Battery low-voltage alarm.
6. Engine high-temperature shutdown.
7. Lube-oil, low-pressure shutdown.
8. Overspeed shutdown.
9. Remote emergency-stop shutdown.
10. Engine high-temperature prealarm.
11. Lube-oil, low-pressure prealarm.
12. Fuel tank, low-fuel level for both main and belly tanks.
13. Low coolant level.
14. Generator supplying load.
15. Generator breaker trip or open.
16. Generator ground fault alarm.
17. Fuel overflow/critical high level alarm.

F. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.

1. Overcrank shutdown.
2. Coolant low-temperature alarm.
3. Control switch not in auto position.
4. Battery-charger malfunction alarm.
5. Battery low-voltage alarm.
6. Engine high-temperature shutdown.
7. Lube-oil, low-pressure shutdown.
8. Overspeed shutdown.
9. Remote emergency-stop shutdown.
10. Engine high-temperature prealarm.
11. Lube-oil, low-pressure prealarm.
12. Fuel tank, low-fuel level for both main and belly tanks.
13. Low coolant level.
14. Generator supplying load.
15. Generator breaker trip or open.
16. Generator ground fault alarm.
17. Fuel overflow/critical high level alarm.

G. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push buttons shall be protected from accidental operation and located as indicated.

1. Shipped loose for contractor installation at closest roof access door to the generator enclosure.
2. On exterior of generator enclosure readily accessible from closest access point on roof. Switch shall be installed by generator enclosure manufacturer.
3. (2) Shipped loose for contractor installation in the fire command center

2.6 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Disconnect Switch: Molded-case type, 100 percent rated.

1. Rating: Matched to generator output rating.
2. Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.

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3. Auxiliary and Bell Alarm: Provide contacts for annunciation on the generator control and remote annunciator panel that the generator unit mounted circuit breaker has been tripped or opened.
- B. Generator Overcurrent Protective Relay: Provide a UL listed / CSA certified generator protection relay integrated with the generator control system, coordinated with the alternator to prevent damage to the generator set on overload or fault conditions external to the machine.

The protective relay shall provide the following functions, as a minimum:

1. Overvoltage (59): Phase overvoltage shutdown, adjustable 105–125% of nominal with 0.1–10 s adjustable delay.
 2. Undervoltage (27): Phase undervoltage shutdown, adjustable 50–95% of nominal with 2–20 s adjustable delay.
 3. Underfrequency (81U): Adjustable 2–10 Hz below nominal with 5–20 s delay.
 4. Overfrequency (81O): Adjustable 2–10 Hz above nominal with 1–20 s delay.
 5. Overcurrent / thermal protection: Adjustable long-time protection based on alternator thermal damage curve; no instantaneous trip required.
 6. Loss of sensing voltage shutdown.
 7. Field overload shutdown.
 8. Overload (kW) warning.
 9. Reverse power (32): Adjustable 5–20% of rated kW with time delay.
 10. Reverse VAR protection: Adjustable 15–50% of rated VARs with time delay.
 11. Short-circuit protection coordinated to prevent alternator damage while permitting downstream protective device operation.
 12. Maintenance / arc-flash reduction mode: Provision for a maintenance mode that reduces incident energy at the generator terminals by increasing sensitivity or speed of protective functions, in compliance with NEC 240.87 where applicable.
- C. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

2.7 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1.
- B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
- C. Electrical Insulation: Class H .
- D. Temperature Rise: 105 degree C over 40 degree C ambient.
- E. Stator-Winding Leads: Provide random wound windings to ensure performance and reduce waveform harmonic distortion caused by non-linear loads such as UPS's and high pulse VFD's. The windings shall be brought out to terminal box to permit future reconnection for other voltages if required..

- F. Generator shall be capable of accepting a single-step load equal to at least 70% of the generator's nameplate kVA rating, with voltage recovery to a minimum of 90% rated no-load voltage within 1.0 second, in accordance with NEMA MG1.
- G. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- H. Enclosure: Dripproof.
- I. Instrument Transformers: Mounted within generator enclosure.
- J. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
 - 1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
- K. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
- L. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- M. Subtransient Reactance: 11 percent, maximum.

2.8 LOAD BANK

- A. General: An engine radiator airflow cooled, resistive load bank is required for permanent, on site installation as a free-standing unit. The load bank shall be designed for local, automatic control.
- B. Electrical Connection: Power source to load bank connection is 3-phase, 3-wire plus ground. Additional control wire connections for remote control as required.
- C. Load Bank Rating:
 - 1. Capacity: 50% generator load, 1.0 p.f.
 - 2. Load Steps 50 KW load step resolution.
 - 3. Voltage: 480V AC, 3-ph., 3-W.
 - 4. Frequency: 60 Hertz.
 - 5. Air intake temperature: 155°F maximum (radiator air outflow).
 - 6. Airflow requirements: Radiator air outflow.
 - 7. Duty Cycle: Continuous.
 - 8. Air temp. rise: 100°F, nominal.
 - 9. Air back pressure: .25-50" water column.
- D. Load Bank Design:
 - 1. General: The load bank shall be a completely self-contained unit which includes all resistive load elements, load control devices, load element branch circuit fuse protection, main load bus and terminals, control terminals, system protection devices and enclosure of required type.

2. The load bank shall be the manufacturer's standard product that has been investigated, tested and listed by Underwriters Laboratories as a system for the purpose intended.
 3. Enclosure: Type 3R, welded sheet steel, UL approved finished painted consisting of an epoxy primer and a polyurethane top coat, consisting of a power section, for installation and wiring of the load elements and a control section for installation and wiring of control components. The control section is to be physically and thermally isolated from both the hot load elements and the heated airflow. Mounting adapters suitable for the installation method selected shall be supplied with the load bank. The exhaust of the load bank shall be screened and, if installed outdoors, louvers shall be provided.
- E. Load elements: Load elements shall be UL listed, labeled or recognized. Helically wound, chromium alloy, thermally derated to 60%. 5% tolerance, 2% balance. .995 p.f. element wire mechanically supported over entire length such that if a wire should break, the broken wire segments will not short to adjacent conductors or to ground. Load elements are individually serviceable and replaceable in the field without major disassembly of the load bank.
- F. Load element short circuit protection: Branch circuit fuses, per each 50KW load branch circuit. Fuses shall be 200,000 A.I.C current limiting type.
- G. Load control: One magnetic contactor per each fused branch circuit.
- H. Load Bank Power Wiring: 150°C insulated.
- I. Control Wiring: 105°C insulated.
- J. Control power shall be derived internally from the main load bus. Control and protective circuits shall operate at 120V via control power transformer or line-neutral circuit and shall be fused. All power wiring shall be connected to the generator enclosure panelboard.
- K. System protection: The load bank shall include a comprehensive protection system to protect against overheating. The system shall function to disconnect the load elements from the power source and activate an alarm upon sensing a loss of cooling airflow, or an exhaust air temperature greater than 300°F.
- L. Automatic disconnection: The load bank shall include automatic disconnection operation to immediately disconnect the load bank from the generator in a safe manner in order to facilitate connection of emergency loads. The automatic disconnection shall be interconnected with the ATS control system.
- M. Local Control Panel:
1. A type 1 control panel for automatic and manual operation shall be provided. The panel shall include:
 - a. Control power on-off push-buttons
 - b. "Normal operation" indicator lamp
 - c. Master load control switch
 - d. Load step control switches
 - e. "Cooling failure" alarm indicator lamp

f. Remote control panel shall be UL listed.

N. Remote Control Panel:

1. Remote control of the load bank shall be provided by the remote ATS control panel.

O. Noise Criteria

1. Noise Criteria: The load bank unit with its integral enclosure shall produce a sound pressure level no more than 78 dBA at a distance of 23 ft in any horizontal direction from the unit, at an elevation about equal to the top of the unit, in a free field condition. This noise emission limit shall specifically include noise emissions from the casing panels, air inlet, air discharge, and engine exhaust, and this shall be made clear as part of a submittal. The supplier shall provide at the submittal stage, evidence to support their claim of meeting this requirement such as measurement data for a similar package or calculations that a person knowledgeable in noise control can follow

2.9 OUTDOOR SOUND ATTENUATED FACTORY SKIN-TIGHT GENERATOR-SET ENCLOSURE

- A. Description: UL-2200 listed sound attenuated, skin-tight, pre-engineered aluminum-clad with integral structural-steel frame enclosure package. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Instruments, control, and battery system shall be mounted within enclosure.

1. Sound Attenuation Level: When installed and operating at rated load, the generator set and enclosure shall not exceed 74.1 dBA at 23 feet in a free-field condition.

- B. Description: Pre-fabricated or pre-engineered, aluminum-clad, integral structural-steel-framed, erected on concrete foundation.

- C. Structural Design and Anchorage: Comply with ASCE/SEI 7 for wind loads of up to 150 mph.

- D. The combined height of the generator base rails, sub-base day tank, and enclosure threshold shall be limited such that no stairs, ladders, or elevated platforms are required to safely access, operate, or maintain the generator set or enclosure in compliance with applicable OSHA requirements (29 CFR 1910 Subpart D), NFPA 110, and AHJ standards.

1. The vendor shall provide a sub-base configuration that allows all routine maintenance activities—including checking fluids, draining fluids, replacing filters, operating the output breaker, operating local controls, and accessing doors and panels—to be performed from finished grade, without the need for elevated means of access.
2. If the proposed sub-base height would necessitate an elevated working surface or stair access under OSHA rules, the vendor shall revise the sub-base design so the generator can be fully maintained from grade level.

- E. Finish: Zinc phosphate pre-treatment, e-coat primer and super durable powder topcoat paint to minimize corrosion and color fade. Manufacturer's standard finish color.
- F. Cambered roof to prevent water accumulation.
- G. Hinged Doors: Recessed lockable doors on both side of the unit. Include retainers to hold doors open for easy access. Each door must have a drip rail over to divert running rain water away from the doors.
- H. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine generator components.
- I. Non-hygroscopic sound attenuating enclosure lining material.
- J. Interior acoustic insulation shall be covered with a durable, factory-applied protective scrim or facing suitable for service in a generator enclosure and compliant with UL 2200.
- K. Muffler Location: Within enclosure.
- L. Space Heater: Thermostatically controlled and sized to prevent condensation
- M. Automatic Dampers: At engine cooling-air inlet and discharge louver dampers. Both air intake & air discharge dampers shall be motor closed/spring open to reduce enclosure heat loss in cold weather when unit is not operating. Should the damper motor fail the dampers should automatically open.
- N. Provide an internally mounted and wired electrical distribution panel to serve the engine generator and enclosure AC electrical features, including"
 - 1. AC load distribution panelboard inside the generator enclosure connected to a 120/208 volts AC – 3-phase utility service by the installer.
 - a. Factory wired normal AC service from the panelboard to the engine coolant heater, alternator heater, battery charger, AC lights and automatic open/close louver dampers, convenience outlets.

2.10 VIBRATION ISOLATION DEVICES

- A. Restrained Spring Isolators: 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. Ace Mountings Co., Inc.
 - b. California Dynamics Corporation.
 - c. Isolation Technology, Inc.

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- d. Kinetics Noise Control, Inc.
- e. Mason Industries, Inc.
- f. Vibration Eliminator Co., Inc.
- g. Vibration Isolation.
- h. 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 psig (3447 kPa).
 - 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.

2.11 FINISHES

- A. Indoor and Outdoor Enclosures and Components: Enclosure manufacturer's standard color as selected by Architect over corrosion-resistant pretreatment and compatible primer.

2.12 SOURCE QUALITY CONTROL

- A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
 1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.
- B. Project-Specific Equipment Tests: Before shipment, factory test engine-generator, load bank, and enclosure and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests in addition to any standard manufacturer's tests:
 1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
 2. 1 hour full load run.
 3. Maximum power.
 4. Voltage regulation.
 5. Transient and steady-state governing in 10% steps up to full load.
 6. Single-step load pickup.
 7. Safety shutdown.
 8. Provide 14 days' advance notice of tests and opportunity for observation of tests by Owner's representative.
 9. Report factory test results within 10 days of completion of test.

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10. Verification of enclosure sound level performance.
11. Any additional tests which may be required by the Commissioning Agent.
12. Owner will witness all required factory tests. Notify Architect at least 14 days before date of tests and indicate their approximate duration.
13. Contractor shall provide all flights, lodging, transportation, and meals required for (4) owner's representatives to witness the factory testing described above.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.
- B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Prior to installation complete and submit all required Massachusetts State permitting forms including but not limited to the Massachusetts Department of Environmental Protection Installation Compliance Certification for New Emergency Engines. Obtain all approvals from Massachusetts State and the City of Worcester prior to starting-up generator.
- B. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
- C. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- D. Install packaged engine generator on cast-in-place concrete equipment bases where shown on grade. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 1. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
 2. Comply with requirements for vibration isolation devices specified in this section.
- E. Install roof-mounted generators on rooftop dunnage provided by others. Coordinate mounting and support points with dunnage design.
- F. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet.

Flexible connectors and steel piping materials and installation requirements are specified in Section 232116 Hydronic Piping Specialties."

1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Section 232116 Hydronic Piping Specialties."

- G. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.
- B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
- C. Connect cooling-system water piping to engine-generator set and with flexible connectors.
- D. Connect engine exhaust pipe to engine with flexible connector.
- E. Connect fuel piping to engines with a gate valve and union and flexible connector.
 1. Diesel storage tanks, tank accessories, piping, valves, and specialties for fuel systems are specified in Section 231113 "Facility Fuel-Oil Piping."
- F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 IDENTIFICATION

- A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems"

- specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
 3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
 - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
 - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - c. Verify acceptance of charge for each element of the battery after discharge.
 - d. Verify that measurements are within manufacturer's specifications.
 4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
 5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
 6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
 7. Exhaust Emissions Test: Comply with applicable government test criteria.
 8. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
 9. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
 10. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.
- C. Coordinate tests with tests for transfer switches and run them concurrently.
- D. Test instruments shall have been calibrated within the last 12 months, traceable to standards of NIST, and adequate for making positive observation of test results. Make calibration records available for examination on request.
- E. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

- H. Remove and replace malfunctioning units and retest as specified above.
- I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- K. Provide all fuel required for complete testing and any re-testing required. Generator fuel storage tank and belly tank shall be provided full of fuel at completion and acceptance of project.
- L. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.
 - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.
 - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators. Refer to Section 017900 "Demonstration and Training."

END OF SECTION

SECTION 26 41 13

LIGHTNING PROTECTION FOR STRUCTURES

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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 lightning protection system for ordinary structures.
- B. Related Requirements:
 - 1. Section 260526 "Grounding and Bonding for Electrical Systems" for general requirements and procedures.

1.3 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, ground rings, conductor supports, splices, and terminations, including concealment requirements.
 - 4. Include roof attachment details, coordinated with roof installation.
 - 5. Calculations required by NFPA 780 for bonding of metal bodies.

1.4 INFORMATIONAL SUBMITTALS

- A. 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 the 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.
 - B. Qualification Data: For Installer.
 - C. Product Certificates: For each type of roof adhesive for attaching the roof-mounted air terminal assemblies, approved by the roofing-material manufacturer.
 - D. Field quality-control reports.
- 1.5 CLOSEOUT SUBMITTALS
- A. Maintenance Data: For lightning protection system to include in maintenance manuals.
 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Dimensioned site plan showing dimensioned route of the ground loop conductor and the ground rod locations. Comply with requirements of Section 017839 "Project Record Documents."
 - b. A system testing and inspection record, listing the results of inspections and ground resistance tests, as recommended by NFPA 780, Annex D.
 - B. Completion Certificate:
 1. UL Master Label Certificate.
- 1.6 QUALITY ASSURANCE
- A. Installer Qualifications: UL-listed installer, category OWAY.

PART 2 - PRODUCTS

- 2.1 MANUFACTURERS
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. ERICO; brand of nVent Electrical plc.
 2. Harger Lightning & Grounding; business of Harger, Inc.
 3. Heary Bros. Lightning Protection Co. Inc.
 4. Robbins Lightning, Inc.
 5. Thompson Lightning Protection, Inc.
- 2.2 PERFORMANCE REQUIREMENTS
- A. NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for Class I buildings.

- B. UL Lightning Protection Standard: Comply with UL 96A requirements for Class I buildings.
- C. Lightning Protection Components, Devices, and Accessories: Listed and labeled by a qualified testing agency as complying with UL 96, and marked for intended location and application.
 - A. Materials:
 - 1. All materials for this installation shall be as defined by Underwriters Laboratories UL 96.
 - 2. Copper shall be of the grade ordinarily required for commercial electrical Work, generally designated as being 98 percent conductivity when annealed.
 - a) Copper components shall not be used on aluminum surfaces.
 - 1) Air terminal:
 - a) Early Streamer Emission (ESE) air terminal
 - 1. 5/8" x 12" chrome plated copper
 - 2. Chrome plated copper support structure and sphere
 - 3. Threaded air terminal
 - 2) MAST
 - a) Aluminum or stainless steel mast with threaded connection for the ESE air terminal and bonding plate for cable connection.
 - b) Mast support, depending upon application, may be roof mounting base, side mounting base or structural support.
 - c) 24" stainless steel "relief" air terminals shall be used at adjacent flues.
 - 3) Conductors:
 - a) Copper Cable
 - 1. Copper 28 strands of 14 gauge copper ropelay wire, 115,000 circular mils, weighing not less than 375 lbs. per 1000 ft.
 - 2. The structural steel shall be used in lieu of down conductors.
 - a. Every other column or an average of 60'-0" intervals shall be bonded and connected to the ground system.
 - 4) Attachments:
 - a) Fasteners shall be of suitable configuration for the intended application and of the same material as the conductor. Nails,

screws or bolts employed to secure the fasteners shall be stainless steel.

- 5) Connections and Splices:
 - a) Connectors and splices shall be of suitable configuration and type for the intended application and of the same materials as the conductor.
- 6) Ground Rods:
 - a) 3/4" x 10'-0" copper-bond ground rods with two-bolt copper ground rod clamp.
 - b) Two delta ground grids shall be installed for each lightning mast.
 - c) 24" x 24" x 20 gauge copper ground plates may be used in lieu of ground rods if soil conditions do not allow driving of ground rods.
- 7) Provide ground loop / counterpoise located 12" min. below grade.
 - a) 28 strands 14-gauge, 115,000 circular mils, net weight 375 lbs. /1000ft. bare copper conductor (minimum).
 - b) Provide ground rod every 60'-0" average and interconnect with ground loop conductor.
 - c) Ground rods shall be 3/4" x 10'-0" copperbond, minimum. They shall be connected to the system with a two-bolt copper clamp having a minimum length of 1-1/2" and employing stainless steel cap screws.
 - d) Bond to structural steel every 60'-0" average.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install lightning protection components and systems according to UL 96A.
 - B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches (203 mm) in radius and narrow loops.
 - C. Conceal conductors within normal view from exterior locations at grade within 200 feet (60 m) of building. Comply with requirements for concealed installations in UL 96A.
1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning

protection components to ensure compatibility with the roofing specifications and warranty.

2. Install conduit for all down conductors.
 3. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.
- D. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

3.2 CONNECTIONS

- A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.
- B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: high compression.
- C. 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 any adjacent parts.
 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3.3 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 or corrosion of conductors.

3.4 FIELD QUALITY CONTROL

- A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
1. Perform inspections as required to obtain a UL Master Label for system.
- B. Prepare test and inspection reports and certificates.

END OF SECTION

SECTION 26 43 13

SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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 field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.
- B. Related Requirements:
 - 1. Section 26 24 13 "Switchboards" for factory-installed SPDs.
 - 2. Section 26 24 16 "Panelboards" for factory-installed SPDs.

1.3 DEFINITIONS

- A. Inominal: Nominal discharge current.
- B. MCOV: Maximum continuous operating voltage.
- C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.
- D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.

- E. OCPD: Overcurrent protective device.
- F. SCCR: Short-circuit current rating.
- G. SPD: Surge protective device.
- H. VPR: Voltage protection rating.

1.4 REFERENCES

- A. SPD units and all components shall be designed, manufactured, and tested in accordance with the latest applicable standards
 - 1. ANSI/UL 1449 4th Edition or later
 - 2. ANSI/UL 1283 5th Edition or later (Type 2 applications)
 - 3. IEEE C62.41.1
 - 4. IEEE C62.41.2
 - 5. IEEE C62.43-2005
 - 6. IEEE C62.45-2002
 - 7. IEEE C62.48-2005
 - 8. IEEE C62.62-2010
 - 9. UL 96A
 - 10. NFPA 780
 - 11. FCC Part 15, Subpart B and ICES-003 – Radiated Emissions (for surge protection devices with communication capabilities)
 - 12. FCC Part 15, Subpart B and ICES-003 – Conducted Emissions (for surge protection devices with communication capabilities)

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

1.6 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample Warranty: For manufacturer's special warranty.

1.7 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For SPDs to include in maintenance manuals.

1.8 QUALITY ASSURANCE

- A. The manufacturer of the electrical distribution equipment shall be the manufacturer of the SPD within the listed electrical distribution equipment.
- B. For the equipment specified herein, the manufacturer shall be ISO 14001 and ISO 9001 or 9002 certified.
- C. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of twenty-five (25) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- D. The SPD shall be compliant with the Restriction of Hazardous Substances (RoHS) Directive 2011/65/EU and have a visible label showing compliance.
- E. The SPD shall be UL 1449 current edition listed, 20 kA In Type 1 or Type 2 for use in UL 96A systems.
- F. Testing Agency Qualifications: Accredited by NETA.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- G. Source Limitations: Obtain SPD and all power distribution equipment through one source from a single manufacturer.

- H. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.9 WARRANTY

- A. The manufacturer shall provide a ten (10) year warranty (15 year warranty with registration) that covers replacement of the complete unit, including lightning, from the date of shipment against any SPD part failure when installed in compliance with manufacturer's written instructions and any applicable national or local electrical code.

1.10 DELIVERY, STORAGE AND HANDLING

- A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of manufacturer's instructions shall be included with the equipment at time of shipment.

PART 2 - PRODUCTS

2.1 GENERAL SPD REQUIREMENTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Shall be the same manufacturer as the distribution equipment manufacturer.
- B. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. MCOV of the SPD shall be the nominal system voltage.
- D. SPD's shall be multi-stage parallel connected device.
- E. Unit Operating Voltage – Refer to drawings for operating voltage and unit configuration.

- F. Maximum Continuous Operating Voltage (MCOV) – The MCOV shall not be less than 115% of the nominal system operating voltage.
- G. The suppression system shall incorporate thermally protected metal-oxide varistors (MOVs) as the core surge suppression component for the service entrance and all other distribution levels. The system shall not utilize silicon avalanche diodes, selenium cells, air gaps, or other components that may crowbar the system voltage leading to system upset or create any environmental hazards. End of life mode to be open circuit. Unit with end of life short-circuit mode are not acceptable.
- H. Unit shall operate without the need for an external overcurrent protection device (OCPD), and be listed by UL as such. Unit must not require external OCPD or replaceable internal OCPD for the UL Listing.
- I. Nominal Discharge Current (In): All SPDs applied to the distribution system shall have a 20kA In rating regardless of their SPD Type (includes Types 1 and 2) or operating voltage. SPDs having an In less than 20kA shall be rejected.
- J. ANSI/UL 1449 4th Edition Voltage Protection Rating (VPR) – The maximum ANSI/UL 1449 4th Edition VPR for the device shall not exceed the following:

MODES	208Y/120	480Y/277	600Y/347
L-N; L-G; N-G	700	1200	1500
L-L	1200	2000	3000

- K. Maintenance Free Design: The SPD shall be maintenance free and shall not require any user intervention throughout its life. SPDs containing items such as replaceable single-mode modules, replaceable fuses, or replaceable batteries shall not be accepted. SPDs requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPDs requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.
- L. Balanced Suppression Platform: The surge current shall be equally distributed to all MOV components to ensure equal stressing and maximum performance. The surge suppression platform must provide equal impedance paths to each matched MOV. Designs incorporating replaceable SPD modules shall not be accepted.
- M. Electrical Noise Filter: Each Type 2 unit shall include a high-performance EMI/RFI noise rejection filter. Noise attenuation for electric line noise shall be up to 50 dB

SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

from 10 kHz to 100 MHz using the MIL-STD-220A insertion loss test method. Products unable able to meet this specification shall not be accepted.

1. Type 1 units shall not contain filtering or have a UL 1283 5th Edition Listing.
 2. Type 2 units with filtering shall conform to UL 1283 5th Edition
- N. Internal Connections: No plug-in component modules or printed circuit boards shall be used as surge current conductors. All internal components shall be soldered, hardwired with connections utilizing low impedance conductors.
- O. Monitoring Diagnostics: Each SPD shall provide the following integral monitoring options:
1. Protection Status Indicators: Each unit shall have a green / red solid-state indicator light that reports the status of the protection on each phase.
 - a. For wye configured units, the indicator lights must report the status of all protection elements and circuitry in the L-N and L-G modes. Wye configured units shall also contain an additional green / red solid-state indicator light that reports the status of the protection elements and circuitry in the N-G mode. SPDs that indicate only the status of the L-N and L-G modes shall not be accepted.
 - b. For delta configured units, the indicator lights must report the status of all protection elements and circuitry in the L-G and L-L modes
 - c. The absence of a green light and the presence of a red light shall indicate that damage has occurred on the respective phase or mode. All protection status indicators must indicate the actual status of the protection on each phase or mode. If power is removed from any one phase, the indicator lights must continue to indicate the status of the protection on all other phases and protection modes. Diagnostics packages that simply indicate whether power is present on a particular phase shall not be accepted.
- P. Remote Status Monitor: The SPD must include Form C dry contacts (one NO and one NC) for remote annunciation of its status. Both the NO and NC contacts shall change state under any fault condition.
- Q. Thermal MOV Protection:

1. The unit shall contain thermally protected MOVs. These self-protected MOVs shall have a thermal protection element integrated with the MOV and a mechanical disconnect with arc quenching capabilities in order to achieve overcurrent protection of the MOV. The thermal protection assembly shall disconnect the MOV(s) from the system in a fail-safe manner should a condition occur that would cause them to enter a thermal runaway condition.
- R. Fully Integrated Component Design: All of the SPD's components and diagnostics shall be contained within one discrete assembly. The use of plug in single-mode modules that must be ganged together in order to achieve higher surge current ratings or other functionality shall not be accepted.
- S. The SPD shall minimize potential arc flash hazards by containing no single-mode plug in user serviceable / replaceable parts and shall not require periodic maintenance. SPDs containing items such as replaceable single-mode plug in modules, replaceable fuses, or replaceable batteries shall not be accepted. SPDs requiring any maintenance of any sort such as periodic tightening of connections shall not be accepted. SPDs requiring user intervention to test the unit via a diagnostic test kit or similar device shall not be accepted.
- T. SPDs designed to interface with the electrical assembly via conductors shall require no user contact with the inside of the unit. Such units shall have any required conductors be factory installed.

2.2 SERVICE ENTRANCE AND GENERATOR SWITCHBOARD SUPPRESSOR

- A. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 1.
- B. Service entrance located SPDs shall be tested and designed for applications within ANSI/IEEE C62.41 Category C environments.
- C. SCCR: Equal or exceed 200 kA.
- D. Comply with UL 1283.
- E. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 250kA and each mode shall not be less than

125kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

- F. Audible Alarm and Silence Button: The SPD shall contain an audible alarm that will be activated under any fault condition. There shall also be an audible alarm silence button used to silence the audible alarm after it has been activated.
- G. Surge Counter: The SPD shall be equipped with an LCD display that indicates to the user how many surges have occurred at the location. The surge counter shall trigger each time a surge event with a peak current magnitude of a minimum of $50 \pm 20A$ occurs. A reset pushbutton shall also be standard, allowing the surge counter to be zeroed. The reset button shall contain a mechanism to prevent accidental resetting of the counter via a single, short-duration button press. In order to prevent accidental resetting, the surge counter reset button shall be depressed for a minimum of 2 seconds in order to clear the surge count total.
 - 1. The ongoing surge count shall be stored in non-volatile memory. If power to the SPD is completely interrupted, the ongoing count indicated on the surge counter's display prior to the interruption shall be stored in non-volatile memory and displayed after power is restored. The surge counter's memory shall not require a backup battery in order to achieve this functionality.

2.3 SWITCHBOARD REQUIREMENTS

- A. SPDs: Comply with UL 1449, Type 2.
- B. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 160kA and each mode shall not be less than 80kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- C. SCCR: Equal or exceed 200 kA.
- D. The SPD shall be factory installed integral to the switchboard at the assembly plant by the original equipment manufacturer
- E. Locate the SPD on the load side of the main disconnect device, as close as possible to the phase conductors and the ground/neutral bar.

- F. The SPD shall be connected through a disconnect (30A circuit breaker). The disconnect shall be located in immediate proximity to the SPD. Connection shall be made via bus, conductors, or other connections originating in the SPD and shall be kept as short as possible.
- G. The SPD shall be integral to switchgear, switchboard, MCC, and/or bus plug as a factory standardized design.

2.4 PANELBOARD SUPPRESSORS

- A. SPDs: Comply with UL 1449, Type 2.
- A. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 120kA and each mode shall not be less than 60kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- B. SCCR: Equal or exceed 200 kA.
- C. Comply with UL 1283.
- D. The SPD shall not limit the use of through-feed lugs, sub-feed lugs, and sub-feed breaker options.
- E. SPDs shall be installed immediately following the load side of the main breaker. SPDs installed in main lug only panelboards shall be installed immediately following the incoming main lugs.
- F. The panelboard shall be capable of re-energizing upon removal of the SPD.
- G. The SPD shall be integral to the panelboard and connected directly to the bus. Alternately, an integral SPD can be connected to a circuit breaker for disconnecting purposes, in the case a disconnect is required.
- H. The SPD shall be included and mounted within the panelboard by the manufacturer of the panelboard.
- I. The complete panelboard including the SPD shall be UL67 listed

2.5 EXTERIOR BRANCH CIRCUITS

- A. Provide exterior distribution hubs for centralized surge protection, including enclosure to house required SPD, for all required circuits leaving the interior of the building and serving exterior loads. Basis of design is ASCO model 459 exterior circuit surge protection hub or engineer approved equal.
- B. SPDs: Comply with UL 1449, Type 2.
- C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 50kA and each mode shall not be less than 20kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- D. SCCR: Equal or exceed 200 kA.
- E. Fully Integrated Component Design: All of the SPD's components and diagnostics shall be contained within one discrete assembly. The use of plug in single-mode modules that must be ganged together in order to achieve higher surge current ratings or other functionality shall not be accepted. The SPD shall be factory installed at the assembly plant by the original equipment manufacturer integral to an enclosure external from the panelboard/ switchboard.
- F. The SPD application covered under this section includes lighting and distribution panelboards. The SPD units shall be tested and demonstrate suitability for application within ANSI/IEEE C62.41 Category B environments.
 - 1. The SPD shall not limit the use of through-feed lugs, sub-feed lugs, and sub-feed breaker options.
 - 2. SPDs shall be installed on the load side of the main breaker to a feeder breaker sized appropriately based on the SPD conductor.
 - 3. Lead length between the breaker and SPD shall be kept as short as possible to ensure optimum performance. Any excess conductor length shall be trimmed in order to minimize let-through voltage. The installer shall comply with the manufacturer's recommended installation and wiring practices.
- G. Provide as indicated on drawings or as required by Florida Building Code (FBC) and Florida Agency for Health Care Administration (AHCA).

2.6 ENCLOSURES

A. Indoor Enclosures: NEMA 250, Type 4.

1. Constructed of ANSI 61 painted steel intended for either indoor or outdoor use to provide a degree of protection against access to hazardous parts; to provide a degree of protection of the equipment inside the enclosure against ingress of solid foreign objects (dirt and windblown dust); to provide a degree of protection with respect to the harmful effects on the equipment due to the ingress of water (rain, sleet, snow, splashing water, and hose directed water); and that will be undamaged by the external formation of ice on the enclosure.

PART 3 - EXECUTION

3.1 FACTORY TESTING

- #### A.
- Standard factory tests shall be performed on the equipment under this section. All tests shall be in accordance with the latest version of NEMA, IEEE, and UL standards.

3.2 INSTALLATION

- #### A.
- Comply with NECA 1.
- #### B.
- Install an OCPD or disconnect as required to comply with the UL listing of the SPD.
- #### C.
- Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
- #### D.
- Use crimped connectors and splices only. Wire nuts are unacceptable.
- #### E.
- Wiring:
1. Power Wiring: Comply with wiring methods in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

2. Controls: Comply with wiring methods in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

F. Complete connections to monitoring system as required.

G. Locate external SPD either below or above the associated distribution equipment closets to the incoming main breaker or MLO lugs, side mount will not be acceptable.

H. Feeder Tap Rule

1. The unit shall comply with the NEC 240.21(B)(1)(b) requirements for tap rule when using conductors not over 10 feet on the line side of the service entrance.
2. The disconnect shall be integral to the unit and be protected by barriers to ensure no exposure to harmful voltages.
3. The unit shall have barriers and lockout provisions inside the enclosure in order to safely replace the SPD unit when an end of life condition occurs.
4. Units shall have barriers and lockout provisions to enable replacement of the SPD without requiring a system shutdown.

3.3 COORDINATION

A. Coordinate location of field mounted surge suppressors to allow adequate clearances for maintenance.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.

1. Compare equipment nameplate data for compliance with Drawings and Specifications.
2. Inspect anchorage, alignment, grounding, and clearances.
3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. An SPD will be considered defective if it does not pass tests and inspections.

- C. Prepare test and inspection reports.

3.5 STARTUP SERVICE

- A. Complete startup checks according to manufacturer's written instructions.
- B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.
- C. Energize SPDs after power system has been energized, stabilized, and tested.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION

SECTION 26 51 00

LUMINAIRES

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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. Interior luminaires, light sources, power supplies, and accessories.
 - 2. Exterior luminaires, light sources, power supplies, and accessories.
 - 3. Emergency lighting units.
 - 4. Luminaire supports.
- B. Related Requirements:
 - 1. Division 26 Section "Network Lighting Controls" for lighting control systems.
 - 2. Division 26 Section "Wiring Devices" for manual wall-box control devices.
 - 3. Division 26 Section "Schedules for Lighting" for full details of scheduled luminaires.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. CU: Coefficient of utilization.
- D. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.
- E. Fixture: See "Luminaire."
- F. IP: International Protection or Ingress Protection Rating.
- G. LED: Light-emitting diode.

- H. LER: Luminaire efficacy rating.
- I. LOR: Light output ratio. Lumens emitted from Luminaire divided by lumens produced by light source.
- J. Lumens: Unless otherwise noted, refers to delivered total luminous flux exiting a fully assembled luminaire with all specified accessories.
- K. Luminaire: Complete lighting unit, including light source, power supply, reflector, housing and trim if provided.
- L. Pole: Luminaire support structure, including tower used for large area illumination.
- M. RCR: Room cavity ratio.

1.4 REFERENCE STANDARDS

- A. General: Comply with the applicable provisions of the referenced standards except as modified by governing codes and the Contract Documents. Where a recommendation or suggestion occurs in the referenced standards, such recommendation or suggestion shall be considered mandatory. In the event of conflict between referenced standards, this specification or within themselves, the more stringent standard or requirement shall govern.
- B. All luminaires, lighting system equipment, and installation shall comply with all relevant local, state or federal codes, regulations and building inspection standards. Contractor to verify and provide all required labels indicating compliance with above standards, affixed to each luminaire in a position concealing it from normal view.
- C. All luminaires and electrical components installed shall be listed and labeled as defined in NFPA 70, Article 100 by a Nationally Recognized Testing Lab (NRTL) acceptable to the authority having jurisdiction and marked for their intended use. All luminaires shall meet UL standards for Luminaires for installation in their specific locations and shall comply with article 410 of the National Electric Code.
- D. Comply with IEEE C2, "National Electrical Safety Code."
- E. Certified and listed to comply with safety standards for dry, damp, or wet locations, as directed by a Nationally Recognized Testing Laboratory (NRTL).
- F. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
- G. ANSI/IEEE C62.41 – Guide on Surge Voltages in AC Power Circuits Rated up to 600V
- H. ANSI/NFPA 70 – National Electrical Code
- I. ANSI/NFPA 101 – Life Safety Code
- J. ANSI/ASHRAE/IES Standard 90.1 – 2019

- K. ANSI C78.377 – Specifications for the Chromaticity of Solid-State Lighting Products
- L. CIE TC1-69 – Color Rendering
- M. IESNA LM-79 – Approved Method for Electrical & Photometric Measurement of SSL Products
- N. IESNA LM-80 – Approved Method for Lumen Maintenance of LED Light Source
- O. IESNA TM-21 – Projecting Long Term Lumen Maintenance of LED Light Sources
- P. IESNA TM-30 – IES Method for Evaluating Light Source Color Rendition
- Q. IESNA RP-16-10 – Nomenclature and Definitions for Illuminating Engineering
- R. UL 924 – Emergency Lighting and Power Equipment
- S. UL 1598 – Luminaires
- T. UL 8750 – LED Equipment for Use in Lighting Products
- U. USGBC – LEED v4.0 BD+C for New Construction, Core & Shell

1.5 CONTRACT DOCUMENTS

- A. These documents outline design intent for the electric lighting. Where design intent is unclear, the Contractor shall contact the Architect in writing prior to proceeding with specific item that requires clarification.
- B. Where specification refers to Lighting Consultant, this shall mean Arup US, Inc., 60 State Street, Boston, MA 02109.

1.6 WORK INCLUDED

- A. The contractor shall furnish and install a luminaire of the type indicated by designation at each location shown on the drawings. All materials, accessories, and any other equipment necessary for the complete and proper installation of all luminaires included in the contract shall be furnished by the contractor.
- B. Luminaires shall be manufactured in strict conformance with the contract drawings and specifications. Specifications and scale drawings are intended to convey the salient features, function, and character of the luminaire only, and do not undertake to illustrate or set forth every item or detail necessary for the work. Minor details not usually indicated on the drawings nor specified, but that are necessary for the proper completion of luminaire installation, shall be included as if they were herein specified or indicated on the drawings.

- C. The Owner, Architect, and Lighting Consultant shall not be held responsible for omission or absence of any detail, construction feature, etc., that may be required in the production of the luminaires.
- D. The responsibility of accurately fabricating and installing the luminaires to the fulfillment of this specification rests with the contractor.

1.7 BID SUBMITTALS

A. General Information:

- 1. Bids received which omit any portion of these submittal requirements may be deemed non-responsive.
- 2. The cost for preparing the lighting system bid shall be borne solely by the bidder. No part of the cost of preparing the bid shall be incorporated into the bid itself.
- 3. Bids shall be submitted in accordance with the instructions outlined in this document.
- 4. Bidder warrants upon submission of bid that it has reviewed all construction drawings, specifications and related contract documents for the Project and that the bid submitted is inclusive of all labor, materials and supplies required to deliver the complete operational lighting system as specified.
- 5. All equipment proposed and supplied by the bidder shall be new and shall meet or exceed the technical and performance requirements outlined in this Specification.

B. Technical & Pricing Information:

- 1. Bidder shall submit itemized list of all equipment proposed to be supplied. Itemized equipment listings must include all equipment necessary to develop the complete functioning systems, whether or not the equipment is specifically identified in this Specification. Each piece of equipment shall be individually priced. Sub-totals shall be provided for each unique system and sub-system.
- 2. Technical data sheets or other documentation of each major piece of equipment shall be provided upon request to show how each item meets the requirements of the specification.
- 3. Bidder shall submit schematic diagram(s) illustrating conceptual system architecture where proposed equipment/system deviates from this Specification and accompanying documentation.
- 4. Itemized bid pricing shall exclude installation costs, which is to be itemized separately by function.

C. Other Submittal Information:

- 1. Bidder shall identify in the bid submittal any long lead equipment items that may adversely affect the project schedule.
- 2. Manufacturers listed in the luminaire schedule shall be assumed capable of supplying the listed luminaire unless exceptions are set forth in their quotations. Any such exceptions shall immediately be brought to the attention of the Architect.
- 3. Manufacturer shall have not less than 5 years of experience in design and manufacture of luminaires of the type and quality shown, unless otherwise

- specified. Pre-qualification submissions must include a list of completed projects and dated catalog pages or drawings indicating length of experience.
4. Within 14 days of contract award, awarded contractor shall submit a complete list of lighting products intended to be furnished, if they differ from the products indicated in this specification, with manufacturer and catalog designations, along with currently quoted lead times for delivery. Should the contractor anticipate that the delivery schedule of any specified product may adversely impact the construction schedule, it shall be brought to the attention of the Architect at this time.

1.8 SUBSTITUTIONS

- A. Alternate products other than those listed by name in the specification will not be considered without prior written consent from the Lighting Consultant.
- B. Substitutions for the specified lighting products are not acceptable and will not be considered in the bid process. Failure to include one of the specified products as a part of the base bid may, at the discretion of the Architect, invalidate the entire lighting product bid and exclude the contractor from further consideration. Equal manufacturers identification by means of manufacturers' names and catalogue numbers is to establish basic features and performance standards. Any substitutions must meet or exceed these standards.
- C. Qualifications: Within sixty days of placement of order, Contractor must furnish independent photometric tests and samples for all alternative luminaires. If these luminaires fail to comply with the specification requirements at that time, Contractor will furnish acceptable luminaires at no additional cost to Owner and with no delay to the project.
- D. Any submittals for cost reduction alternates or value engineering shall include unit prices for the specified manufacturer, the specified equal manufacturer and the proposed alternate.
- E. The Lighting Consultant shall be the sole judge in determining whether proposed substitutions comply with the specifications and shall reserve the right to reject any proposed substitutions.

1.9 ACTION SUBMITTALS

- A. Unit Prices: Unit cost per luminaire as of the date of bid, represented as the cost to the Electrical Contractor, for reference in relation to any future change order pricing proposals.
- B. Product Data: For each type of product, arranged in order of luminaire designation. Include data on features, accessories, finishes, and the following:
 1. Physical description of luminaire including dimensions, materials, and construction.
 2. Emergency lighting units including battery and charger.

3. Driver/Power Supply
 4. Energy-efficiency data for complete luminaire.
 5. Life, output (CCT, CRI, Lumens) and energy-efficiency data for light sources.
 - a. All luminaires equipped with LED light sources:
 - 1) Color rendering index data R1-R14. Provide initial and 25% of rated life data.
 - 2) Initial Luminaire Lumen Output at 1,000 hours (L1000).
 - 3) Color tolerance data, initial and at 25% of rated life, including the chromaticity coordinates of the bin.
 - 4) Rated power of the luminaire including driver.
 - 5) Power factor of the luminaire including driver, initial and at 25% of rated life.
 - 6) Absolute photometry report in accordance with LM-79-08.
 - 7) LED light source test reports in accordance with LM-80-08.
 - 8) Light Source Color Rendition report in accordance with IES TM-30-18
 - 9) Light source spectral power distribution data for each source at maximum 10 nm increments from 380 nm to 780 nm
 6. Wiring diagrams for power, control, and signal wiring.
 7. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.
 8. Photometric data based on laboratory tests of each luminaire type, complying with IES "Lighting Measurements Testing and Calculation Guides" for each luminaire type outfitted with light source, power supply, and accessories identical to those indicated for the luminaire as applied in this Project.
 9. Photoelectric relays.
 10. Materials, dimensions, and finishes of poles.
 11. Anchor bolts for poles.
 12. Manufactured pole foundations.
- C. Shop Drawings: For continuous linear, nonstandard or custom luminaires. Manufacturer's dimensioned shop drawings shall include but not be limited to:
1. Plans, elevations, sections, and mounting and attachment details.
 2. Complete details of luminaire fabrication and assemblies. Indicate overall and detail dimensions, finishes, material thickness, material types, fabrication methods, support methods, power and control equipment, light sources, type of shielding, reflectors, trims, hinges, gaskets, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Provide provisions for light source replacement and all other information to show compliance with the contract documents.
 4. Include diagrams for power, signal, and control wiring.
 5. Installation instructions.
 6. Detail fabrication and assembly of poles and pole accessories.
 7. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
 8. Foundation construction details including material descriptions, dimensions, anchor bolts, support devices, and calculations, signed and sealed by a professional engineer licensed in the state of installation.
 9. Anchor bolt templates keyed to specific poles and certified by manufacturer.
 10. Method and procedure of pole installation. Include manufacturer's written installation.

11. All drawings shall clearly indicate the contract drawing number of luminaire details used as reference in the development of the shop drawings and the name of the project, architect and Lighting Consultant.

- D. Delegated-Design Submittal: For luminaire supports.
 1. Include design calculations for luminaire supports and seismic restraints.

1.10 INFORMATIONAL SUBMITTALS

- A. Interior 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. Luminaires.
 2. Suspended ceiling components.
 3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches (300 mm) of the plane of the luminaires.
 4. Structural members to which equipment and/or luminaires will be attached.
 5. Initial access modules for acoustical tile, including size and locations.
 6. Items penetrating finished ceiling, including the following:
 - a. Other luminaires.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Ceiling-mounted projectors.
 7. Moldings.
- B. Exterior 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. Luminaires.
 2. Structural members to which equipment and luminaires will be attached.
 3. Underground utilities and structures.
 4. Existing underground utilities and structures.
 5. Above-grade utilities and structures.
 6. Existing above-grade utilities and structures.
 7. Building features.
 8. Vertical and horizontal information.
- C. Qualification Data: For testing laboratory providing photometric data for luminaires.
- D. Product Certificates: For each type of luminaire.
- E. Warranty: Special warranties specified in this Section.

1.11 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation and maintenance manuals.

1. Submit under provisions of Division 1.
2. Provide a list of all light source types used on Project; use ANSI and manufacturers' codes.
3. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.
4. Include replacement parts list.
5. Maintenance, operating, or installation instructions.
6. Warranties for all luminaire types.

B. Field quality-control test reports.

1.12 MAINTENANCE MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. LEDs and light sources: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
 2. Diffusers and Lenses: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
 3. Power Supply Units (Drivers): 1 for every 100 of each type and rating installed. Furnish at least one of each type.
 4. Battery and Charger: 1 for every 20 of each emergency lighting unit.
 5. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

1.13 SAMPLES

- A. Provide one working sample for review of luminaire types as noted in cutsheet package.
- B. Include finish samples for all downlights including baffles and trims; and cylinder downlights including baffles, exterior finishes, and trims; track and track luminaire finishes; and any other luminaires with multiple finish options as part of product data submittals for review by the Architect and Lighting Consultant.
- C. Products submitted that are not listed as basis of design shall include a working sample of the basis of design and the alternative product for direct comparison as part of the submittal review unless otherwise directed by lighting designer.
- D. Working samples shall be organized for review by the Architect, Lighting Consultant, and Owner together in one session organized and scheduled by the Contractor at a time and location agreed by all parties. Each sample shall include the following:
1. Lamps: Specified light source installed.
 2. Accessories: Cords and plugs.
 3. Drivers: For 120V operation.
 4. Controls: Compatible stand-alone controller available for connection to demonstrate dimming and color changing capabilities, if applicable.

1.14 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications:
 - 1. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
 - 2. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
- B. Provide luminaires from a single manufacturer for each luminaire type.
- C. All materials, equipment and parts comprising the units specified herein shall be new.
- D. All luminaires shall be manufactured to a consistent level of quality. Size, color and components parts shall be identical for all Luminaires.
- E. Mockups: For architectural mock-ups requiring fully powered luminaires, include complete with all accessories, power and control connections.
 - 1. Obtain Architect's approval of luminaires in mockups before starting installations.
 - 2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 - 3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 - 4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
- F. Ceiling coordination mockup: For the AD04 series and AD12 series luminaires integrated with the ceiling channel system, a complete mock-up of the installation shall be prepared as part of the submittal process for review by the Architect and Lighting Consultant.
- G. Construction mockups: Prior to the complete installation of all luminaires of the types below, provide in-situ mockup for review and approval by the design team prior to proceed with full installation. Mockups shall include:
 - 1. AL04 cove lighting
 - 2. AL05 façade lighting features (up and down conditions)
 - 3. AL10 cove lighting
 - 4. AL14 cove lighting
 - 5. AL20 cove lighting
- H. Mockup scheduling:
 - 1. Contractor shall coordinate meeting time for reviewing mockups in a timely fashion according to the sequence of construction and access to luminaires, with at least 2 week notice and 2 options of day and time for the review session.
 - 2. Contractor shall coordinate mockups to be reviewed concurrently.
 - 3. Contractor shall plan this into their work schedule, coordinating with timing of access requirements, scaffolding, etc. and including additional days for

contractor access after initial aiming, for corrections to be made while access remains available.

- I. Installer's Qualifications: Installer shall have at least 2 years of successful installation experience on projects with luminaire work similar to that required for project.

1.15 COORDINATION

- A. Coordinate layout and installation of luminaires and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, sound system, partition assemblies, etc.

1.16 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.
- B. Ship equipment in its original packages to prevent damage or entrance of foreign matter. All handling must be performed in accordance with manufacturers recommendations.
- C. Replace, at no expense to Owner, equipment or material damaged during storage or installation as directed by the Architect.

1.17 FIELD CONDITIONS

- A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.
- B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

1.18 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period. Replacement of faulty materials and the cost of labor required to make the replacement shall be the responsibility of the Contractor.
 1. Failures include, but are not limited to, the following:
 - a. Structural failures, including luminaire support components.
 - b. Faulty operation of luminaires and accessories.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 2. Warranty Period: five years from date of Substantial Completion.
- B. Warranty for LED Luminaires: Manufacturer's standard form on complete LED luminaire assembly (driver, LED module, luminaire housing), in which luminaire

manufacturer agrees to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Warranty Period for LED Luminaires: Five years from date of Substantial Completion.
 2. Warranty shall be by luminaire manufacturer as the sole source of service.
- C. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
1. Warranty Period for Emergency Lighting Unit Batteries: Ten years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.
 2. Warranty Period for Emergency LED Driver and Self-Powered Exit Sign Batteries: Seven years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining six years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. The following requirements apply to product selection:
1. Basis-of-Design Product: The design for each luminaire is based on the product named. Subject to compliance with requirements, provide either the named product or a product by a listed acceptable manufacturer, equal in all recognizable characteristics. Bids not including manufacturers as explicitly noted will not be accepted.
 2. Other manufacturers: Acceptance of a luminaire other than from the specified manufacturer must be requested by RFI prior to Submittal. Alternative manufacturer RFI must include unit price of specified luminaire and proposed luminaire. A working sample request will be made in response to such an RFI for inclusion with Submittal.

2.2 PERFORMANCE REQUIREMENTS

- A. Operating Parameters:
1. All components for interior use shall be designed to operate properly between 50°F and 115°F without increased failure rate.
 2. All components for exterior use shall be designed to operate properly between 0°F and 120°F without increased failure rate.
 3. Relative Humidity: Zero to 95 percent.
- B. Thermal Protectors
1. Provide thermal protectors as required by the NEC, or as required by local code, to prevent operation of luminaires in enclosed spaces or adjacent to combustible materials at temperatures at or above 90°C (194°F).
 2. Luminaires listed for operation in fire-resistant material at temperatures up to 150°C (302°F) shall be plainly marked.

2.3 LUMINAIRE AND COMPONENT REQUIREMENTS

- A. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 - 1. Label shall include the following lamp characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter, shape, size, wattage, and coating.
 - c. CCT and CRI.
- B. NRTL Compliance:
 - 1. Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.
 - 2. Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.
- C. Markings of Luminaires:
 - 1. Markings shall be clear and located to be readily visible to service personnel, but invisible from normal viewing angles when lamps are in place.
 - 2. Luminaires designed for voltages other than 110-125 volts shall be marked with operating voltage.
 - 3. Luminaires designed for operation of lamps below the rated enclosure maximum shall be clearly marked 'Lamp Watts Not to Exceed _____' to maintain the design energy load.
- D. Recessed luminaires shall comply with NEMA LE 4.
- E. Total luminaire, light source, and power supply assembly for luminaires, including all components must be inaudible and without perceptible flicker at full output and when dimmed to 1% output. Components found to cause perceptible audible sounds or flicker must be replaced with corrected or alternative components, for up to six months after Substantial Completion.
- F. Emergency circuits: Where luminaires are circuited to both normal and emergency circuits, provide independent power connection to emergency segments, with physical separation within luminaire of all emergency wiring, such that normal and emergency wiring do not share the same wire paths within conduit, junction boxes, or luminaires.
- G. Electromagnetic-Interference Filters: Factory installed to suppress conducted electromagnetic-interference as required by MIL-STD-461E. Fabricate luminaires with one filter on each ballast indicated to require a filter.

2.4 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

- A. Comply with UL 773 or UL 773A.
- B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc (16 to 32 lx) and off at 4.5 to 10 fc

(48 to 108 lx) with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.

1. Relay with locking-type receptacle shall comply with ANSI C136.10.
2. Adjustable window slide for adjusting on-off set points.

2.5 LED LUMINAIRES AND LIGHT SOURCES

- A. To account for the continual development of LED light source efficacy all luminaires equipped with LED are specified noting the lumen output required.
- B. Color Tolerance
 1. Unless otherwise specified, all white LED light sources shall achieve a minimum color tolerance within a 3-step MacAdam ellipse, measured for both initial and at 25% of rated life across all LEDs in each luminaire type. Color tolerance beyond this is unacceptable.
 2. Base CCT shall be per specification. All LEDs supplied must be within a tolerance of +/-100K from base color temperature.
 3. Chromaticity Tolerance shall be no more than 0.03 on the CIE chromaticity diagram from the black body curve.
- C. Color Rendering
 1. Color rendering index (CRI) of all LED light sources shall achieve the minimum CRI specified initially and at 25% of rated life.
 2. No variation in CRI between initial and 25% rated life is acceptable.
 3. All CRI (R_a) values must be greater than 80 unless otherwise specified.
- D. Life
 1. Lifetime testing of LED light sources shall be carried out in accordance with LM-80-08. All LED light sources shall achieve a minimum performance of L70, where rated life of the LED light source is defined as the time taken to reach 70% of the initial lumen output.
 2. Unless otherwise indicated, all LED light sources shall achieve a minimum lifetime of 50,000 hours at L70.
 3. Unless otherwise indicated, all LED light sources shall not exceed a failure fraction of 10% (F10) at rated life (L70).
- E. Dimming
 1. All luminaire types shall dim to 1% unless otherwise noted, without flicker.
- F. Flicker
 1. Light source in combination with specified control shall provide "reduced flicker operation" when tested at 100 percent and 20 percent of full light output, where reduced flicker operation is defined as having percent amplitude modulation (percent flicker) less than 30 percent at frequencies less than 200Hz, tested according to the requirements in California Title 24, Joint Appendix JA-10.
- G. Ultraviolet Light Output (UV)
 1. Light output power at 400nm and below shall be 0.
- H. Power Factor

1. LED drivers shall achieve a minimum power factor of 0.9

I. Maintenance

1. Both LED module and driver shall be able to be replaced without soldering or sending the luminaire back to the manufacturer. Quick-connect devices are preferred.

2.6 LED DRIVERS

A. General

1. Drivers shall operate for at least 50,000 hours at maximum case temperature and 90 percent non-condensing relative humidity.
2. Driver must limit inrush current.
 - a. Base specification: Meet or exceed NEMA 410 driver inrush standard of 430 Amps per 10 Amps load with a maximum of 370 Amps² – seconds.
 - b. Preferred Specification: Meet or exceed 30mA²s at 277VAC for up to 50 watts of load and 75A at 240us at 277VAC for 100 watts of load.
3. Withstand up to a 1,000 volt surge without impairment of performance as defined by ANSI C62.41 Category A.
4. Total Harmonic Distortion less than 10% percent and meet ANSI C82.11 maximum allowable THD requirements at full output. THD shall at no point in the dimming curve allow imbalance current to exceed full output THD.
5. Driver must support automatic adaptation, allowing for future luminaire upgrades and enhancements and deliver improved performance:
 - a. Adjustment of forward LED voltage, supporting 3V through 55V.
 - b. Adjustment of LED current from 150mA to 1.4A at the 100 percent control input point in increments of 1mA
 - c. Adjustment for operating hours to maintain constant lumens (within 5 percent) over the 50,000 hour design life of the system, and deliver up to 20 percent energy savings early in the life cycle.
6. Driver must be able to operate for a (+/- 10%) supply voltage of 120V through 277VAC at 60Hz.
7. Driver should be UL Recognized under the component program and shall be modular for simple field replacement. Drivers that are not UL Recognized or not suited for field replacement will not be considered.
8. Driver shall include ability to provide no light output when the analog control signal drops below 0.3 V , or the DALI/DMX digital signal calls for light to be extinguished and shall consume 0.5 watts or less in this standby. Control dead band between 0.3V and 0.65V shall be included to allow for voltage variation of incoming signal without causing noticeable variation in luminaire to luminaire output.
9. Drivers shall operate at 60kHz plus or minus 5%. Drivers shall be inaudible with no apparent humming or buzzing at any point in the dimming range.
10. Drivers shall have luminaire/lamp crest factor less than 1.6 per ANSI C82.11-1993.
11. Drivers shall include inrush current limiting circuitry and end-of-lamp life protection.
12. Drivers shall be capable of striking lamps at any light levels without first flashing to full light.

13. Multi luminaire drivers shall track evenly, with no perceptible difference in light levels for the same luminaire types.
14. Allow for emergency operation.
15. Provide thermal fold-back protection by automatically reducing power output (dimming) to protect LED driver and LED light engine/luminaire from damage due to over-temperature conditions that approach or exceed the LED driver's maximum operating temperature at calibration point.
16. Provide integral recording of operating hours and maximum operating temperature to aid in troubleshooting and warranty claims.
17. Designed and tested to withstand electrostatic discharges without impairment when tested according to IEC 61000-4-2.
18. Class A sound rating; Inaudible in a 27 dBA ambient.
19. Offer programmable output currents in 10 mA increments within designed driver operating ranges for custom luminaire length and lumen output configurations, while meeting a low-end dimming range of 100 to 0.1 percent, 100 to 1 percent, or 100 to 5 percent as applicable.
20. The EEPROM or flash card in each driver shall be able to recover from loss of power. Life time of each EEPROM or flash card shall be equal to the life time of the driver. Program must only allow one address at any given time. The program shall provide luminaire status, driver status, luminaire output and failure modes with address.
21. Complies with FCC requirements of CFR, Title 47, Part 15, for commercial applications at 120-277 V and residential applications at 120 V.

B. Performance

1. Over the entire range of available drive currents, driver shall provide step-free, continuous dimming down to the percent light output indicated. Driver shall respond similarly when raising from 0% to 100%
 - a. Driver must be capable of 20 bit dimming resolution for white light LED drivers or 15 bit resolution for RGBW LED drivers.
2. Driver must be capable of configuring a linear or logarithmic dimming curve, allowing fine grained resolution at low light levels
3. Drivers to track evenly across multiple luminaires at all light levels, and shall have an input signal to output light level that allows smooth adjustment over the entire dimming range.
4. Driver and luminaire electronics shall deliver illumination that is free from objectionable flicker as measured by flicker index (ANSI/IES RP-16-10). At all points within the dimming range from 100-0.1 percent luminaire shall have:
 - a. LED dimming driver shall provide continuous step-free, flicker free dimming similar to incandescent source.
 - b. Base specification: Based on IEEE PAR1789, minimum output frequency should be greater than 1250 Hz.
 - c. Preferred specification: Flicker index shall be equal to incandescent, less than 1% at all frequencies below 1000 Hz
5. Demonstrate no visible change in light output with a variation of plus or minus 10 percent change in line-voltage input.
6. Automatically go to 100 percent light output upon loss of control link voltage and lock out system commands until control link voltage is restored. Manufacturer to offer UL 924 compliance achievable through use of external interface upon request.

- C. Control Input – As indicated in Luminaire Schedule or Data Sheets
 - 1. 4-Wire (0-10V DC Voltage Controlled) Dimming Drivers
 - a. Must meet IEC 60929 Annex E for General White Lighting LED drivers
 - b. Connect to devices compatible with 0 to 10V Analog Control Protocol, Class 2, capable of sinking 0.6 ma per driver at a low end of 0.3V. Limit the number of drivers on each 0-10V control output based on voltage drop and control capacity.
 - c. Must meet ESTA E1.3 for RGBW LED drivers
 - 2. (DALI Low Voltage Controlled) Dimming Drivers
 - a. Must meet IEC 62386
 - 3. Digital Multiplex (DMX Low Voltage Controlled) Dimming Drivers
 - a. Must meet DMX / RDM: USITT DMX512A and ANSI E1.20 (Explore & Address)
 - b. Capable of signal interpolation and smoothing of color and intensity transitions
 - 4. 3-Wire Dimming Drivers
 - 5. Forward Phase (2-Wire) Dimming Drivers
- D. Construction
 - 1. Drivers shall be free of Polychlorinated Biphenyls (PCBs)
 - 2. Driver controls shall be polarity free.
 - 3. Manufactured in a facility that employs ESD reduction practices in compliance with ANSI/ESD S20.20.
 - 4. UL 8750 recognized or listed as applicable.
 - 5. UL Type TL rated where possible to allow for easier luminaire evaluation and listing of different driver series.
 - 6. UL 1598C listed for field replacement as applicable.
 - 7. Designed and tested to withstand Category A surges of 4,000 V according to IEEE C62.41.2 without impairment of performance.
- E. Life
 - 1. 50,000 hours lifetime, minimum.
 - 2. Driver failure rate per 1000 hours operating at 60 deg Celsius ambient, shall be 0.2 % or less.
- F. Input
 - 1. 120 – 277 V, 60 Hz, unless otherwise noted.
- G. Testing
 - 1. All drivers shall be 100% factory tested. Testing protocol shall be submitted with bid proposal and shall include reliability, and longevity.
- H. Installation
 - 1. Employ integral fault protection up to 277 V to prevent LED driver damage or failure in the event of incorrect application of line-voltage to communication link inputs.
 - 2. Provide integral fault protection to prevent driver failure in the event of a mis-wire
 - 3. LED driver may be remote located up to 100 feet (30 m) from LED light engine, or as noted in other requirements, depending on power outputs required and wire gauge utilized by installer.

2.7 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

- A. Structural Characteristics: Comply with AASHTO LTS-4.
- B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts, unless otherwise indicated.
- C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
 - 1. Materials: Shall not cause galvanic action at contact points.
 - 2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication, unless stainless-steel items are indicated.
 - 3. Anchor-Bolt Template: Plywood or steel.
- D. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."
- E. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.
- F. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4.

2.8 MATERIALS

- A. Metal Parts:
 - 1. Free of burrs and sharp corners and edges.
 - 2. Sheet metal components shall be steel unless otherwise indicated.
 - 3. Form and support to prevent warping and sagging.
- B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
- C. Steel:
 - 1. ASTM A36/A36M for carbon structural steel.
 - 2. ASTM A568/A568M for sheet steel.
- D. Stainless Steel:
 - 1. Manufacturer's standard grade.
 - 2. Manufacturer's standard type, ASTM A240/240M.
- E. Galvanized Steel: ASTM A653/A653M.

- F. Aluminum: ASTM B209.
- G. Bronze: copper alloy, principal alloying elements are phosphor, aluminum, silicon and tin
- H. Brass: copper alloy, principal alloying element is zinc. Wrought brass is of UNS designation C20000, C30000, C40000, C66400 to C69800. Cast brass includes leaded red brass (C83600), leaded semi red brass (C84400), and yellow and leaded yellow brass (C85200 to C85700).
- I. Copper: a pure metal. Copper or high copper alloy containing less than 6% alloying elements. Wrought copper has UNS designation C10000. Cast copper has UNS designation C80100 to C82800.
- J. Zinc: a pure metal. May be specified as an alloying element in copper and aluminum.
- K. Diffusers, Covers, and Globes:
 - 1. Acrylic Lighting Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - a. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless different thickness is indicated.
 - b. UV stabilized.
 - 2. Glass: Annealed crystal glass, unless otherwise indicated.
- L. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- M. Neoprene: all neoprene rubber should be heat resistant to withstand heat generated by lamp operation.
- N. Silicone: plastic based on silicon which is not an organic compound. Suitable for use in a wide temperature range (-80 to +500° F). Used as an additive to plastic to improve adhesion, increase strength and improve water resistance.
- O. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
 - 4. Laminated Silver Metallized Film: 90 percent.

2.9 FABRICATION

- A. Provide thickness of metal required or as specified so that all luminaires are rigid, stable and will resist deflection twisting, warping or bending under normal installation procedures, loading, relamping, etc. or no less than as follows:
 - 1. All steel luminaire housings minimum 22 gauge cold rolled steel
 - 2. All aluminum extrusion housings minimum 0.125" thick

3. All spun, hydroformed, or sheet aluminum reflectors fabricated from #12 aluminum sheets, minimum 15 gauge, 0.57" or heavier
 4. All acrylic lenses minimum 0.1875" thick
 5. All glass lenses minimum of 0.375" thick
 6. All cast aluminum or bronze housings minimum of 0.375" thick
 7. All sheet bronze, steel, aluminum or other metal plate minimum of 22 gauge
- B. Provide neoprene or silicone gasketing, stops, and barriers where required to prevent light leak or water and water vapor (penetration).

2.10 FINISHES

- A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color with support and mounting components.
- C. Factory-Applied Finish for Aluminum luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
 3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
 4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611
- D. Factory-Applied Finish for Steel luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
 2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

2.11 WIRING

- A. All wiring within the luminaires or from the luminaire to the splice with the project branch circuit shall comply with the following:
 - 1. Wiring between lampholders and associated operating and starting equipment shall be of similar or heavier gauge than the leads furnished with the approved types of ballasts with equal or better insulating and heat resisting characteristics.
 - 2. Wiring shall be protected with tape or tubing at all points where abrasion may occur.
 - 3. Wiring shall be concealed within the luminaire construction except where design or mounting dictates otherwise.
 - 4. Connections of wires to light sources, power supplies, control units, and other accessories shall be made in a neat and workmanlike manner and electrically and mechanically secure with no protruding or loose strands. The number of wires extending to or from the light sources, power supplies, control units, or other accessory shall not exceed the number which the accessory is designed to accommodate.
 - 5. Wiring channels and wireways shall be free from projections and rough or sharp edges throughout and all points or edges over which conductors must pass and may be subject to injury or wear, shall be rounded and bushed.
 - 6. Insulated bushings shall be installed at points of entrance and exit of flexible wiring.
 - 7. Junction boxes attached to luminaires shall be manufactured in accordance with the National Electrical Code and listed for the number of conductors indicated on the drawings. Supplementary junction boxes shall be installed where required to comply with Code.
 - 8. All exposed wire shall be jacketed with a flexible woven fiberglass sleeve or similar flexible metallic or armored cable (BS) or EMT type conduit.
 - 9. When exposed, all junction boxes and conduit to be painted as per the architects' direction.

2.12 REFLECTORS

- A. Reflectors and reflecting cones or baffles shall be as follows:
 - 1. Absolutely free of any tooling marks, including spinning lines, indentations caused by riveting or other assembly techniques
 - 2. No rivets, springs or other hardware visible after installation
 - 3. First quality polished, buffed and anodized finish, 'Alzak' or equal
 - 4. Specular finish color as selected by the architect or as specified.
 - 5. All reflector and baffles of modified elliptical contour, with no apparent brightness from above 40° above the nadir, with no lamp image or any part of the lamp visible from above 40° above the nadir
 - 6. Cone flange formed as an integral part of the cone and with identical color and finish unless otherwise noted. Width of the flange covers all ceiling opening without light leaks or hardware visible.
- B. Other aluminum reflectors shall be as follows:
 - 1. Formed and finished as noted on the drawings and elsewhere in the specification

2. Reflectors free from blemishes, scratches or indentations which would distort their reflective function
 3. Finished by means of the 'Alzak' process or equal unless otherwise noted.
- C. Samples of colored aluminum finishes (black, brass, bronze etc) shall be submitted for review before fabrication.
- D. All reflectors shall be finished according to the minimum requirements outlined in the following table:

Classes	Minimum Weight of Coating mg/sq in	Service	% Minimum Reflectivity	
			Specular	Diffuse
MI	0.5	Normal interior service.	83	75
SI	7.5	Medium service, interior industrial, exterior when operated within glass.	82	73
SE	10	Exterior industrial or commercial service, exposed to atmosphere. Marine service enclosure	78	65
M	13	Marine service, not protected by enclosure	78	65

2.13 LENSES

- A. All lenses secured by positive means with neoprene or silicone gasketing or washers as required to hold the lens tight within a frame or attach to a housing.
- B. All glass lenses shall be heat treated (tempered) or sealed with a clear acrylic laminate layer to provide a 'safety glass' rating. All lenses that require removal for relamping or normal maintenance shall be attached to the luminaire housing by a minimal length of safety chain to prohibit the lens from falling and striking surrounding surfaces. Glass edges exposed during the relamping process gasketed to prevent chipping or cracking.
- C. Glass lenses specified as translucent or 'opal' shall be treated as follows:
1. Sand blasted
 2. Acid etched
 3. White flashed
- D. Acrylic lenses shall be 100% virgin acrylic polymer, colorless, as manufactured by Rohm Hass, or Dupont.
- E. The quality of the raw acrylic material must exceed IES, SPI and NEMA specifications by at least 100% which, as a minimum standard, shall not exceed yellowness factor of 3 after 2000 hours of exposure in the Fade-o-meter or as tested by an independent test laboratory. Acrylic plastic lenses and diffusers shall be properly cast, molded or

extruded as specified and shall remain free of any dimensional instability, discoloration, embrittlement, or loss of light transmittance for at least 15 years.

2.14 LOUVERS

- A. All louvers shall be fabricated of the specified material.
- B. Louver finishes shall be provided as specified.
- C. All plastic parabolic louvers shall be destaticised before and after fabrication to insure minimum maintenance.
- D. All metal louvers shall be coated with anti-rust material and electrostatically painted.
- E. All louvers shall be heat tested to withstand lamp-operating temperatures with no deformation of shape, paint blistering or discoloration.

2.15 EMERGENCY LIGHTING

- A. Emergency lighting installation shall adhere to applicable code for project location.
- B. Designated emergency luminaires shall be provided with emergency power from a generator, separate service, central battery, or distributed battery packs.
- C. When battery packs are used to supply power for emergency lighting, an appropriate test apparatus shall be installed in accordance with the applicable code.
- D. Emergency power for emergency lighting shall be capable of operating for a duration of 90 minutes without falling below 60% of initial light output.

2.16 LUMINAIRE SUPPORT

- A. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.
- C. Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single luminaire. Finish same as luminaire.
- D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).
- E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage (2.68 mm).

- F. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
- G. Hook Hangers: Integrated assembly matched to luminaire and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Prior to ordering suspended or surface mounted continuous row luminaires for walls, coves, soffits, valances or cabinets, verify overall lengths with the architectural drawing layouts and details or specialty craft shop drawings.
- B. Recessed Downlights: Review architectural drawings for insulation details and provide luminaires suitable for use in direct contact with insulation where required.
- C. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- D. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

- A. Unless otherwise indicated, permanently installed new luminaires shall not be used for construction illumination or otherwise turned on prior to completion of construction, other than as necessary for testing, commissioning and focusing.
- B. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

- A. Comply with NECA 1.
- B. The Contractor shall coordinate exact quantities and critical dimensions with field conditions.
- C. The Contractor shall verify and coordinate that appropriate framing, support structures, mounting brackets and other required structural connections are provided by the general contractor or other trades to ensure a timely, neat installation of all luminaires.

- D. The Contractor shall coordinate and provide any associated mounting hardware, conduit connections, or associated appurtenances to effectively install the luminaires. Provide each luminaire with complete installation instructions. All luminaires to be installed in strict conformance with manufacturer's recommendations and instructions.
- E. Exact locations and orientations of all luminaires including mounting heights and plan dimensions shall be per the architectural drawings. Any ambiguities or conflicts in this dimensional information shall be identified to the Architect prior to installation.
- F. Do not install exposed luminaires, reflectors or trims until all plastering and painting that may mar luminaire finish is completed. Replace blemished, dented, damaged or unsatisfactory luminaires as directed.
- G. Support all luminaires independent of ductwork or piping.
- H. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated. Secure according to manufacturer's written instructions and approved Shop Drawings. Support luminaires according to requirements.
- I. Support for Recessed and Semi-recessed Grid-Type luminaires:
 - 1. Units may be supported from suspended ceiling support system. Install ceiling support system rods or wires at a minimum of 4 rods or wires for each luminaire, located not more than 6 inches (150 mm) from luminaire corners.
 - a. Install support clips for recessed luminaires, securely fastened to ceiling grid members, at or near each luminaire corner.
 - b. Luminaires Smaller than Ceiling Grid: Install a minimum of 4 rods or wires for each luminaire and locate at corner of ceiling grid where luminaire is located. Do not support luminaires by ceiling acoustical panels.
 - c. Luminaires of sizes less than ceiling grid: Center in acoustical panel. Support luminaires independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.
- J. Support for Suspended luminaires:
 - 1. Brace pendants and rods over 48 inches (1200 mm) long to limit swinging. Support stem-mounted, single-unit, suspended fluorescent luminaires with twin-stem hangers. For continuous rows, use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of chassis, including one at each end.
- K. Exterior Luminaire Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Able to maintain luminaire position after cleaning and relamping.
 - 3. Support luminaires without causing deflection of finished surface.
 - 4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
- L. Lamping: Where specific lamp designations are not indicated, lamp units according to manufacturer's instructions.

- M. Luminaire attachment for exterior luminaires: Fasten to structurally-sound support by means of manufacturer's installation instructions and approved exterior surface or mounting shop drawings.
- N. Install surface mounted luminaires plumb and adjust to align with building lines and with each other. Secure to prohibit movement.
- O. Exposed Grid Ceilings: Support surface mounted luminaires on grid ceiling directly from building structure.
- P. The Contractor shall rigidly align all continuous rows of luminaires for true in-line appearance.
- Q. Install recessed luminaires using accessories and firestopping materials to meet regulatory requirements for fire rating.
- R. Install accessories furnished with each luminaire.
- S. Install specified light sources in each luminaire.
- T. Install recessed luminaires with trim tight to ceiling, not allowing light leaks onto the ceiling.
- U. Remote mounting of power supplies: Distance between the power supply and light source shall not exceed recommendation of power supply manufacturer. Verify, with power supply manufacturers the maximum allowable distance between power supply and light source.
- V. Install recessed luminaires in plaster or drywall ceilings using plaster frames.
- W. Mechanically bond luminaires mounted end-to-end to insure ground continuity.
- X. Install hangers and spacers as required.
- Y. Install recessed luminaires so that wiring box and replaceable parts are accessible from the ceiling opening.
- Z. Make wiring connections to branch circuit using building wire with insulation suitable for temperature conditions within luminaire.
- AA. Bond products and metal accessories to branch circuit equipment grounding conductor.

3.4 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

- B. Steel Conduits: Comply with Division 26 Section "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.5 GROUNDING

- A. Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding electrode for each pole, unless otherwise indicated.
 - 2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
- B. Ground nonmetallic poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding electrode for each pole.
 - 2. Install grounding conductor and conductor protector.
 - 3. Ground metallic components of pole accessories and foundations.

3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

- A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.
- B. Give advance notice of dates and times for field tests.
- C. Provide instruments to make and record test results.
- D. Perform the following tests and inspections:
 - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper normal operation.
 - 2. Emergency Lighting Tests: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal. Include the following information in tests of emergency lighting equipment:
 - a. Duration of supply.
 - b. Low battery voltage shutdown.
 - c. Normal transfer to battery source and retransfer to normal.
 - d. Low supply voltage transfer.
 - 3. Illumination Tests:
 - a. Measure light intensities at night. Use photometers with calibration referenced to NIST standards.

4. Verify operation of photoelectric controls.
 5. Check for excessively noisy drivers.
 6. Replace or repair malfunctioning luminaires and components, then retest. Repeat procedure until all units operate properly.
 7. Report results of tests.
- E. Replace luminaires that show evidence of corrosion during Project warranty period.

3.8 FOCUS AND ADJUSTMENT

- A. Adjust each aimable luminaire under supervision of Lighting Consultant as designated by Architect.
- B. Contractor shall coordinate meeting time for aiming in a timely fashion according to the sequence of construction and access to luminaires, with at least 1 week notice and 2 options of day and time for each aiming session.
- C. Contractor shall provide for up to 2 aiming sessions after luminaires are installed. Each aiming session is assumed to be a full 8-hour day.
- D. Contractor shall plan this into their work schedule, coordinating with timing of access requirements, scaffolding, etc. and including additional days for contractor access after initial aiming, for corrections to be made while access remains available.
- E. Aiming shall occur with Lighting Consultant and a work crew as determined necessary by Lighting Consultant. All required equipment shall be available for aiming, including ladders or other lift equipment, and lamps and accessories as specified. This work may entail multiple evenings of work, including separate preliminary focus sessions, then final focus.
- F. Where possible away from windows, units shall be focused during the normal working day. Where daylight interferes with seeing, focus shall be accomplished during the night at a time mutually agreeable to Contractor, Lighting Consultant, and Owner. Adjustments shall be made in accordance with the Lighting Consultant's stated intent, under his/her observation.

3.9 TRACK LIGHTING COMPONENTS

- A. Luminaires shall not be installed to track until aiming and adjustment takes place, just prior to the project's completion.
- B. Exact beam distribution of track luminaires will not be known until final aiming and adjustment takes place. Unless beam distribution is specifically indicated on luminaire data sheet, Contractor shall provide 150 percent of total lens or reflector quantities required for each luminaire, with distributions broken down as follows:
 1. 50% Wide Flood
 2. 50% Flood
 3. 50% Spot

- C. Any spare lamps, reflectors, and lenses remaining after final aiming and adjustment will be turned over to the Owner for stock. Any spares that the Owner does not choose to keep for stock shall be returned unopened to the contractor's distributor, for full credit.

3.10 CLEANUP

- A. At the time of final acceptance by the Architect, all luminaires shall have been thoroughly cleaned with materials and methods recommended by the manufacturers, all broken parts shall have been replaced and all lamps shall be operative.

3.11 DEMONSTRATION

- A. Provide systems demonstration under provisions of Division 1.
- B. Provide minimum of two hours demonstration of luminaire operation and maintenance.

END OF SECTION 265100

SECTION 27 05 00

COMMON WORK RESULTS FOR COMMUNICATIONS SYSTEMS (Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section specifies the basic requirements for communications and low voltage installations as indicated or required, and includes requirements common to more than one specification section of Division 27 and 33 (where included) such as related documents, related sections, definitions, governing requirements, contractor requirements, warranty requirements, submittal requirements/procedures, and project closeout requirements/procedures, as well as other requirements.

1.2 RELATED DOCUMENTS

- A. The general provisions of the Contract, including General, Supplementary and other conditions, Division 1, and the requirements of other Divisions apply to the work of this Division.
- B. Examine the Contract Documents in their entirety (including Drawings and Specification Sections in the other Divisions) for requirements or work which may affect work under this Section, regardless of whether such requirements or work are specifically indicated in this Section.

1.3 RELATED SECTIONS

- A. All Division 27 Specification and 33 Sections in this Bid Package
- B. The applicable portions of the Governing Requirements (see Part 1 - General: Governing Requirements, herein) shall be incorporated by reference into each related Specification Section.
- C. Other Division Sections referencing this Section

1.4 QUALIFICATIONS

- A. See Division 1 requirements for contractor general qualifications
- B. Where manufacturer supports an authorized distributor program, products shall be purchased through an authorized distributor. Provide manufacturer's letter of authorization.
- C. Where manufacturer supports a certified installer program, products shall be installed by a certified installer company using certified installers. Provide certification documents.

1.5 INTENT AND INTERPRETATIONS

- A. It is the intent of the Construction Documents that the Contractor shall include all items necessary for the proper execution and completion of the Work by the Contractor, resulting in complete and fully operational system(s) ready for the Owner's use, in full compliance with all applicable standards, codes and ordinances.
 - 1. Work or product not specifically indicated in the Construction Documents, but which are necessary to result in complete and fully operational system(s) ready for the Owner's use, shall be provided.
 - 2. The specification of certain products in the Construction Documents shall not be construed as a release from furnishing such additional products and materials necessary to furnish complete and fully operational system(s) ready for the Owner's use.
- B. In the event that discrepancies exist or required items or details have been omitted in the Construction Documents, notify the Consultant in writing prior to the bid date. Failure to do so shall be construed as willingness to provide a complete and fully operational system within the amount of the bid for this work. Where such discrepancies are not brought to the attention of the Consultant, the most stringent requirements shall be construed to be the basis for this bid response.
- C. Prior to bidding the project, bidders shall visit the site to determine all existing conditions affecting the work, the type of construction to be used, and the nature and extent of work provided by other trades. Failure to do so shall be construed as willingness to provide complete and fully operational system(s) within the amount of this bid. Site visit to be coordinated with Owner/general contractor.
- D. Drawings and Specifications are complementary. Items required by either are binding as though they are required by both. In the event of conflict between or within the requirements of the Drawings and the Specifications:
 - 1. With regards to the preparation of proposals and/or bids, the Contractor shall assume the more stringent (costly) condition shall prevail. The Contractor shall notify the Consultant of such prior to the bid date.
 - 2. With regards to actual construction, the Contractor shall notify the Consultant and await the Consultant's instruction prior to proceeding with procurement and installation.
- E. The Construction Documents include certain conventions in the use of language and the intended meaning of certain terms, words, and phrases when used in particular situations or circumstances. These conventions include:
 - 1. Abbreviated Language: Language used may be abbreviated. Implied words and meanings shall be interpreted as appropriate. Words implied, but not stated, shall be interpreted as the sense requires. Singular words shall be interpreted as plural and plural words interpreted as singular where applicable and where the full context so dictates.
 - 2. Imperative and Streamlined Language: Imperative and streamlined language is used generally. Requirements expressed in the imperative mood are to be performed by the Contractor. At certain locations in the text, for clarity, subjective language is used to describe responsibilities that must be fulfilled indirectly by the Contractor, or by others when so noted.

3. Abbreviations and Names: Trade association names and titles of general standards are frequently abbreviated. Where abbreviations and acronyms are used, they mean the recognized name of the trade association, standards generating organization, authority having jurisdiction, or other entity applicable to the context.
 4. Words used in the singular shall also mean the plural, wherever the context so indicates, and likewise words in the plural shall also mean the singular, wherever the context so indicates.
 5. Unless otherwise stated, words which have well known technical or construction industry meanings are used in accordance with such recognized meanings.
 6. The terms "directed", "required", "permitted", "ordered", "designated", or "prescribed", as well as similar words shall mean the direction, requirement, permission, order, designation or prescription of the Consultant.
 7. The terms "approved", "acceptable", "satisfactory", and similar words shall mean approved by, acceptable, or satisfactory to the Consultant.
 8. The terms "necessary", "reasonable", "proper", "correct" and similar words shall mean necessary, reasonable, proper, or correct in the judgment of the Consultant.
- F. Assignment of Specialists: The individual Specification Sections may require that certain specific construction activities be performed by specialists who are recognized experts in the operations to be performed. The specialists must be engaged for those activities, and such assignments are requirements over which the Contractor has no choice or option. Nevertheless, the ultimate responsibility for fulfilling the contract requirements shall remain with the Contractor.
- G. Drawings:
1. Drawings are diagrammatic and approximate in character, are not intended to show all features of required work, and do not necessarily indicate every required component.
 2. Symbols used on the Drawings are defined in the legend on the Drawings. Some symbols indicated on the legend may not necessarily be required.

1.6 DEFINITIONS

- A. The definitions below are applicable to this Division. These definitions supplement the definitions specified in Division 1. In the event of discrepancies between these definitions and those defined in Division 1, the definitions in Division 1 shall take precedence.
1. Accepted/Acceptable: Work or materials conforming with the intent of the project, and in general, conforming to the pertinent information in the Construction Documents in the opinion of the Consultant or other designated Owners' Representative.
 2. Approved/Approval: The written approval of the Consultant.
 3. Accessible: Easy access. Access attained without requiring extensive removal of other materials to gain access, and additionally as prescribed by governing requirements.
 4. Accessible Ceiling: Acoustical tile hanging ceilings. "Hard-lid" ceilings (concealed spine or sheetrock/gypsum ceilings), specialty architectural ceilings and any ceiling larger than 2 ft. x 4 ft. (even when provided with access panels) are not considered an Accessible Ceiling.

5. Agreement: The contractual agreement between the General Contractor or Owner and the Contractor or as indicated in Division 1.
6. Concealed: Hidden from sight in interstitial building spaces, chases, furred spaces, shafts, crawl spaces, etc.
7. Construction Documents: Collective term for the entire set of bound or unbound material describing the construction and services required, including all Drawings, Specifications, addenda issued prior to execution of the contract, and modifications issued after execution of the Contract (such as change orders, construction change directives, supplemental instructions, etc.).
8. Contract Documents: The Agreement (including other documents listed in the Agreement), Conditions of the Contract (General, Supplementary and other conditions), and the Construction Documents.
9. The Contract: The Contract Documents form the Contract. The Contract represents the entire and integrated agreement between the Owner and the Contractor and supersedes any prior negotiations, representations or agreements, either written or oral. The Contract shall not be construed to create a contractual relationship of any kind (1) between the Consultant and the Contractor, (2) between the Owner and a Subcontractor, or (3) between any persons or entities other than the Owner and Contractor.
10. Contractor: The party (or parties) responsible for providing the system(s) as indicated herein.
11. Drawings: The graphic and pictorial portions of the Contract Documents, wherever located and whenever issued, showing the design, location and dimensions of the Work, generally including (but not limited to) plans, elevations, sections, details, schedules and/or diagrams.
12. Engineer/Consultant: The party responsible for producing the communications system(s) Construction Documents.
13. Exposed: Not concealed (see above) and not installed underground
14. Final Completion: The date when the Consultant or other designated Owners' Representative confirms in writing that the Contractor has completed the work in accordance with the Construction Documents, including completion of all punch list items, cleanup work and delivery of all required guarantees, warranties, licenses, releases and other required deliverables.
15. Furnish: To purchase, supply, and deliver to the project materials in new and operable condition, ready for installation.
16. Governing Requirements: Collective term for regulations, laws, ordinances, codes, rules, standards, requirements, and guidelines that govern the installation and inspection of the work defined in the Contract Documents. See Part 1 – General: Governing Requirements herein.
17. Governing Authorities: Entities or their representatives charged with formation and/or enforcement of Governing Requirements, such as the Authority Having Jurisdiction (AHJ).
18. Install: To place in final position in fully operable, tested condition.
19. Inside Plant (ISP): Infrastructure within a building.
20. Or Equal, Or Approved Equal, Or Equivalent, Or Approved Equivalent: Materials that are deemed, in the opinion of the Consultant or other designated Owner representative, to be dimensionally suitable, the same in appearance, and are operationally identical, to the specified item.
21. Outside Plant (OSP): Infrastructure exterior to a building.
22. Owner: The Owner and the Owner's designated representative(s).
23. The Project: The total construction of which the Work performed under the Contract Documents may be the whole or a part, and which may include construction by the Owner and/or separate contractors.
24. Provide: To furnish and install, complete, tested and ready for intended use.

25. Substantial Completion: The date when all work required by the Construction Documents shall be designated in writing as complete (subject to the final punch list to be prepared by the Consultant or other designated Owners' Representative) and on which the applicable jurisdictional authorities have issued a temporary certification of occupancy.
26. Section: An individual section of the Specifications.
27. Shown on Drawings: Noted, indicated, scheduled, detailed, or any other written reference made on the Drawings.
28. Specifications: The portion of the Contract Documents consisting of the written requirements for materials, equipment, construction systems, standards and workmanship for the Work and performance of related services.
29. Specification Section(s): One or more sections of the Specifications.
30. Section(s): An abbreviated form of Specification Section(s).
31. The Work: The construction and services required by the Contract Documents, whether completed or partially completed, and all other labor, materials, equipment and services provided or to be provided by the Contractor to fulfill the Contractor's obligations. The Work may constitute the whole or a part of the Project.

1.7 ABBREVIATIONS

- A. Refer to the individual Specification Sections and Drawings for abbreviations and their definitions.

1.8 GOVERNING REQUIREMENTS

- A. All work shall be executed in compliance with the latest version and applicable portions of the codes, regulations, standards, guidelines, and/or recommendations of the following (hereinafter referred to as Governing Requirements):

1. General

- a. ACI: American Concrete Institute (www.aci-int.org)
- b. AHJ: Authority Having Jurisdiction
- c. ANSI: American National Standards Institute (www.ansi.org)
- d. ASTM: American Society for Testing and Materials (www.astm.org)
- e. ASME A17.1: Safety Code for Elevators and Escalators
- f. BICSI: A Telecommunications Association (www.bicsi.org)
- g. IBC: International Building Code
- h. IFC: International Fire Code
- i. ICEA: Insulated Cable Engineers Association (www.icea.net)
- j. IEEE: Institute of Electrical and Electronic Engineers (www.ieee.org/standards.ieee.org)
- k. IES: Illuminating Engineering Society of North America (www.iesna.org)
- l. FCC: Federal Communications Commission Rules and Regulations
- m. NAB: National Association of Broadcasters
- n. NFPA: National Fire Protection Association (www.nfpa.org)
- o. NEC: National Electrical Code (NFPA Article 70) (www.nfpa.org/www.necdirect.org)
- p. NESC: National Electrical Safety Code (<http://standards.ieee.org/nesc/>)
- q. NEMA: National Electrical Manufacturers Association (www.nema.org)
- r. OSHA: Occupational Safety and Health Administration (www.osha.gov)
- s. TIA: Telecommunications Industry Association (www.tiaonline.org)

- t. UL: Underwriters Laboratories, Inc. (www.ul.com, ulstandardsinfo.net)
 - u. State and local codes, ordinances, and regulations
 - v. Requirements and guidelines of local utility companies
 - w. Applicable state, local and/or federal requirements
 - x. Health Department requirements
 - y. Seismic requirements applicable to this location
 - z. Manufacturer installation guidelines and recommendations
2. Communications Specific:
- a. ANSI/TIA-568 Series: Commercial Building Telecommunications Cabling Standard
 - b. ANSI/TIA-569-E: Commercial Building Standard for Telecommunications Pathways and Spaces
 - c. ANSI/TIA-606-D: Administration Standard for Commercial Telecommunications Infrastructure
 - d. ANSI/TIA-607-D: Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
 - e. ANSI/TIA-758-B: Customer-Owned Outside Plant Telecommunications Infrastructure Standard
 - f. TIA: Technical Service Bulletins (TSBs) (related to the above TIA standards)
 - g. IEEE 802.3: Local Area Network Ethernet Standard, including the IEEE 802.3z Gigabit and 802.3ae and 802.3an 10 Gigabit Ethernet Standard
 - h. BICSI: BICSI Customer Owned Outside Plant Design Manual
 - i. BICSI: BICSI LAN and Internetworking Design Manual
 - j. BICSI: BICSI Telecommunications Distribution Methods Manual
 - k. BICSI: BICSI Telecommunications Cabling Installation Manual
 - l. NEC: NFPA 70
 - m. NFPA 75: Standard for the Fire Protection of Information Technology Equipment
 - n. NFPA 780: Standard for the Installation of Lightning Protection Systems
 - o. FCC Part 68: Connection of Terminal Equipment to Telephone Network.
 - p. FCC Title 47: Telecommunication
 - q. FCC 76.611: Cable Television Basic Signal Leakage Performance Criteria
- B. Work shall comply with the Governing Requirements in effect at the time of construction, including all addenda, errata, annexes, and technical service bulletins (TSBs), etc., except where a specific date or version is otherwise indicated, or where otherwise mandated by a Governing Authority.
- C. In the event of conflict within the Governing Requirements and/or conflict between the Governing Requirements and the Construction Documents:
- 1. With regards to the preparation of proposals and/or bids, the Contractor shall assume the more stringent (costly) condition shall prevail. The Contractor shall notify the Consultant of such prior to the bid date.
 - 2. With regards to actual construction, the Contractor shall notify the Consultant and await the Consultant's instruction prior to proceeding with procurement and/or installation.

3. In the event of conflict between a code and a non-code Governing Requirement, or between a code and the Construction Documents, the code shall govern. However, compliance with code requirements shall not be construed as relieving the Contractor from complying with any requirements of the non-code Governing Requirement or Construction Documents which may be in excess of code requirements and not contrary to same.
4. If the requirements of this section or the Project Drawings exceed those of the governing codes and regulations, then the requirements of this section and the Drawings shall govern. However, nothing in this section or the Drawings shall be construed to permit work not conforming to all governing codes and regulations.
5. Errors or omissions in the Construction Documents do not relieve the Contractor from executing the work in accordance with the Governing Requirements.

D. The Governing Requirements are incorporated by reference into these Specifications.

1.9 PERMITS AND FEES

- A. Permit and Fee requirements shall be in accordance with the applicable portions of 014000 Regulatory Requirements sections. The requirements below supplement the requirements in Sections 014000. In the event of discrepancies between these requirements and those defined in Sections 014000, the more stringent requirements shall take precedence.
- B. Obtain and pay for all licenses, permits and inspections required by the laws, ordinances and rules governing work specified herein. Such fees shall be included in the bid amount.
- C. Schedule and coordinate all inspections of the work as required, and shall provide all assistance as required by the inspector(s) during their inspection(s).
- D. Pay all fees, including but not limited to fees for local utility service installation, connection charges, etc. Such fees shall be included in the bid amount.

1.10 SUBSTITUTIONS AND DEVIATIONS

- A. Substitutions and deviations shall be in accordance with the applicable portions of Section 012500 Substitution Procedures. The requirements below supplement the requirements in Section 012500. In the event of discrepancies between these requirements and those defined in Section 012500, the more stringent requirements shall take precedence.
- B. Prior to award of contract:
 1. Bids shall be based on products and methods of construction as specified.
 2. Substitution of product and deviations from the methods of constructions specified which are used in the Contractor's bid shall be at the sole risk of the Contractor, and as such are subject to rejection without consideration during submittal review, should the Contractor be awarded the contract.

C. After award of contract:

1. Proposed substitution and deviation requests shall be reviewed during the time of Submittal review.
 - a. Conditions for Consideration: Substitution and deviation requests will be received and considered only when one or more of following conditions are satisfied:
 - 1) The specified product or method of construction cannot be provided within the contract period.
 - 2) The specified product or method of construction cannot receive necessary approval by a Governing Authority, and the requested substitution can be approved.
 - 3) The specified product or method of construction cannot be provided in a manner that is compatible with other materials.
 - 4) A substantial advantage is offered to the Owner, in terms of cost, time, or other considerations of merit.
 - 5) The product as specified includes the statement "Or Equal/Equivalent."
 - b. Conditions for Rejection: Substitution and deviation requests will be rejected for the following reasons, among others:
 - 1) The conditions for consideration (see above) have not been met.
 - 2) Extensive revisions to the Construction Documents are required to support the proposed changes.
 - 3) The proposed changes do not comply with the general intent of the Construction Documents.
 - 4) The substitution request is for product which does not include the statement, "Or Equal/Equivalent", or is specified as "no substitute", "substitutions are not acceptable", "provide as specified" or similar.
 - 5) The proposed change is solely for the convenience or economic gain of the Contractor.
2. Approval of substitution and deviation requests
 - a. Do not proceed with a substitution or deviation without written approval.
 - b. The Contractor shall be responsible for fees incurred by the Consultant for any redesign resulting from the proposed changes, and for the updating of the Construction Documents to reflect such changes.

1.11 SUBMITTALS

- A. Submittals shall be in accordance with the applicable portions of Section 013300 Submittal Procedures. The requirements below supplement the requirements in Section 013300. In the event of discrepancies between these requirements and those defined in Section 013300, the most stringent requirements shall take precedence.
- B. General:
 1. Submittal review is a courtesy extended to the Contractor for the limited purpose of checking for general conformance with the design concept and the information shown in the Construction Documents.

2. In the event of discrepancies or conflict between Submittals and the Construction Documents, either prior to or after review, the requirements of the Construction Documents shall prevail.
3. Submission of material for review, regardless of the outcome of the review, does not alter the Contractor's obligation to follow the intent of the Construction Documents, nor the Contractor's responsibility to comply with the Construction Documents.
4. Submittals will not be reviewed and will be returned to the Contractor without review for the following reasons:
 - a. Submittal is partial or incomplete.
 - b. Submittal contains information concerning the proposed implementation of means, methods, procedures, sequences or techniques, temporary aspects of the construction process, or other items, which are the sole responsibility of the Contractor.
 - c. Submittal was not carefully reviewed by the Contractor prior to submission, as evidenced by poor organization, obvious or numerous errors, lack of correlation or cross-referencing, lack of clarity in presentation, or containing Shop Drawings which do not meet the standard of the Construction Drawings.
 - d. Submittal cut sheets covering multiple products and options that do not have arrows or highlights indicating which product or option is being submitted.
 - e. Submittal was submitted directly from the Contractor's subcontractor(s) or vendor(s).
 - f. Subcontractor and/or vendor submittal information was not carefully reviewed and/or approved by the Contractor.
 - g. Submittal does not bear the Contractor's approval stamp, and/or contains subcontractor and/or vendor submittal information which does not bear the Contractor's approval stamp.
 - h. Submittal contains substitution and/or deviation requests, which are not clearly identified as substitution or deviation requests in a separate "Substitution and Deviation Requests" section of the Submittal.
5. Requests for substitution shall only be included under the "Substitution and Deviation Requests" section of the submittal (see below) and shall comply with the requirements of Part 1 – General: Substitutions and Deviations herein. Submission of substitution requests in any other portion of the Submittal does not constitute an acceptable or valid request for substitution, nor will review of such information constitute approval in any manner.

C. Submittal Format:

1. Electronic PDF format.
2. Paper submittals will not be accepted.

- D. Product Data: Submit Product Data information as called for in the individual Specification Sections. Product Data shall include:
1. For all products provide the following product information (as applicable):
 - a. Specification Section to which the product applies.
 - b. Catalog cut sheets, manufacturer data sheets, and/or specification sheets detailing the product, item, assembly and installation. Cut sheets covering multiple products and options shall have arrows or highlights indicating which product or option is being submitted and cross-outs of non-applicable information.
 - c. Highlighted details within the product data that identifies compliance with the Construction Documents or the intent of the Construction Documents.
 - d. Highlighted details within the product data that identifies deviations from the Construction Documents or the intent of the Construction Documents.
 - e. When the specifications include product descriptions, model numbers, part numbers, etc. that have been superseded, changed, or discontinued, the Contractor shall submit a comparable substitution for review with a note indicating purpose of substitution (not to be used for Substitutions and Deviations as indicated in paragraph below.)
 2. For products for which the Contractor is proposing a substitution, include the product as specified in the submittal per the above requirements and list the reference to the proposed substitution in the "Substitution and Deviation Requests" section of the submittal (see below).
 3. Do not provide product quantities (except where requested in RFP as backup) – quantities are the sole responsibility of the Contractor, are not part of the contract, and may not be reviewed.
- E. Shop Drawings: Submit Shop Drawings as called for in the individual Specification Sections. Shop Drawings shall include:
1. Shop drawings shall be provided in PDF format and in form, format and size identical to that of the Construction Drawings (the Construction Drawings set the standard). Shop drawings that are prepared at a resolution making them unreadable when zoomed in to a normal reading size are not acceptable. Shop Drawings that do not meet these standards shall be rejected without review.
 2. For methods of construction for which the Contractor is proposing a deviation, include the method of construction as specified per the above requirements and list the reference to the proposed deviation in the "Substitution and Deviation Requests" section of the submittal (see below).
- F. Technical Drawings: Submit Technical Drawings as called for in the individual Specification Sections.
- G. Samples:
1. Submit Samples as called for in the individual Specification Sections.
 2. Samples shall be indexed and identified in this section. Product samples shall be clearly labeled and correlated to the descriptions in each section.

- H. Substitution and Deviation Requests: For each substitution and/or deviation request, include the following:
1. Whether the request is for substitution of product or deviation from a construction method.
 2. The Specification Section(s) or Drawing to which the request applies.
 3. Reason for the request (Note: the reason must conform to the requirements of Part 1 – General: Substitutions and Deviations herein)
 4. If a substitution, provide:
 - a. Specified product to which the proposed substitution applies.
 - b. Product Data for the substituted product.
 - c. Notation of differences between the proposed substitution and the specified item.
 5. If a deviation, provide:
 - a. Specified method of construction to which the proposed deviation applies.
 - b. Shop Drawing data for the deviation.
 - c. Notation of differences between the proposed deviation and the specified construction method.
 6. Written statement signed by the Contractor stating that the proposed substitution or deviation is equivalent or superior in function, appearance, and quality to the specified product or construction method and that the proposed substitution or deviation will be at no additional cost to the Owner.
- I. Submit Other Information as called for in the individual Specification Sections.
- J. Submittal review:
1. The submittal review will not include review of the accuracy or completeness of details, such as quantities, dimensions, weights or gauges, fabrication processes, construction means or methods, coordination of work with other trades, or construction safety precautions, all of which are the sole responsibility of the Contractor.
 2. Corrections or comments made on the Submittal by the reviewer during the submittal review do not relieve the Contractor from compliance with the requirements of the Construction Documents.
 3. Review of a specific item shall not indicate that the reviewer has reviewed the entire assembly of which the item is a component.
 4. Review does not relieve the Contractor from responsibility for errors, which may exist in the submitted data.
 5. Review of substitutions and deviations:
 - a. The reviewer shall not be responsible for review of substitutions and/or deviations that were not brought to the attention of the reviewer by specific inclusion of the substitution and/or deviation in the Substitution and Deviation Requests section of the Submittal.
 - b. Where a substitution and/or deviation is not included in the Substitution and Deviation Requests section of the Submittal, the procurement and installation of the substitution and/or deviation is at the sole risk of the Contractor.

- c. If the Reviewer does not specifically note substitutions and/or deviations, it remains the Contractor's responsibility to comply with the Construction Documents.
- 6. After review, submittals shall be returned together with review comments and specific actions (if required) to be taken by the Contractor. Typical comments and actions will be:
 - a. "No Exceptions Taken." The submittal appears complete and accurate per the contract documents. Do not re-submit.
 - b. "Make Corrections Noted." The submittal appears complete per the contract documents but includes minor variances from the contract documents. Make the changes noted but re-submission is not required.
 - c. "Amend and Resubmit." The submittal appears substantially complete per the contract documents, but has significant variances from the contract documents. Re-submission is required.
 - d. "Rejected." indicates the submittal is incomplete per the contract documents. Rejected submittals are not reviewed by the Consultant. Re-submission is required.
 - e. "Submit Specified Item." The submittal appears substantially complete and accurate per the contract documents, but is missing an item that the Consultant needs to review. Re-submit only the specified item.
- 7. Perform no portion of the Work requiring a submittal until the respective submittal has been approved by the Architect/Consultant/general contractor. Such Work shall be in accordance with the approved submittal.
- 8. Re-submission of submittals:
 - a. Submittals shall continue to be re-submitted and reviewed until all submitted items are marked by the Consultant as "No Exceptions Taken" or "Make Corrections Noted (Re-submittal Not Required)."
 - b. Re-submittals shall be clearly identified as a re-submittal and shall identify changes on a separate Revisions page inserted after the Table of Contents page(s).
 - c. The Contractor shall be responsible for fees incurred by the Consultant resulting from subsequent review of re-submittals that fail to meet the requirements herein. Such fees will be incurred after the Consultant has reviewed the original submission and one re-submission.

1.12 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store and handle products in full compliance with the manufacturer's recommendations and/or instructions, using means and methods that will prevent damage, deterioration, and loss (including theft).
- B. Protect product until final acceptance.
- C. Protection of product is the sole responsibility of the Contractor. Replace damaged, deteriorated, or lost product at no additional cost to the Owner.
- D. Products subject to damage by the elements shall be stored above ground, under cover, in a weather tight enclosure, with ventilation adequate to prevent condensation. Temperature and humidity shall be maintained within the manufacturer's recommendations.

- E. Make provisions for receiving and storing product, including Owner furnished product to be installed by the Contractor as part of the work.
- F. Carefully inspect for damage upon delivery. Defective or damaged product shall be marked "Rejected", removed from the site, and shall not be installed.
- G. Arrange product deliveries in accordance with the construction schedule. Deliveries shall be scheduled to maintain the progress of work, to avoid conflict with the work of other Trades, and to accommodate site conditions.
- H. Product shall be delivered to the site in the manufacturer's original containers, complete with labels and instructions for the proper handling, storage, unpacking, protection and installation.
- I. Ensure that product to be installed is not temporarily used as steps, ladders, platforms, scaffolds, or for storage by the Contractor or by other Trades during the construction process. Equipment found to be used in such a manner will be considered "damaged", shall not be installed, and shall be replaced at no additional cost to the Owner.
- J. Ensure that cable is not coated with any foreign material such as paint, drywall mud, etc. through the project duration. Cleaning coatings off cabling (beyond small incidental splatters) is not an acceptable remedy. At Owner's discretion, any cabling found with coatings shall be replaced at no additional cost to Owner

1.13 WARRANTY

- A. Contractor Warranty: Provide a Contractor endorsed and backed warranty against all defects in materials and workmanship, in compliance with the applicable requirements of Division 1.
 - 1. All labor and materials attributable to the fulfillment of the warranty (including Contractor administrative costs) shall be provided at no cost to the Owner.
 - 2. Defects in materials and workmanship shall be remedied within 72 hours of discovery and Contractor notification.
 - 3. The Warranty period shall be a minimum of 1 year and shall commence upon Final Completion of the work.
- B. Manufacturer Warranty: Provide Manufacturer Warranty(s) (per system type) as follows:
 - 1. Communications Cabling System: Provide a minimum 20-year Manufacturer extended product, performance/application, and labor warranty:
 - a. Provide a communications cabling system Manufacturer extended product, performance/application, and labor warranty that shall warrant all passive components used in the communications cabling system. Additionally, this warranty shall cover all components not manufactured by the Manufacturer, but approved by the Manufacturer for use in the communications cabling system (i.e. "Manufacturer Approved Alternative Products").

- b. The Manufacturer warranty shall warrant:
 - 1) That the products will be free from manufacturing defects in materials and workmanship.
 - 2) That all cabling products of the installed system shall exceed the specification of ANSI/TIA-568 Series performance standards.
 - 3) That the installation shall exceed the specification of ANSI/TIA-568 Series installation standards.
 - 4) That the system shall be application independent and shall support both current and future applications that use the ANSI/TIA-568 Series component and link/channel specifications for cabling.
 - 5) That all labor (including administrative) and required product attributable to the fulfillment of this warranty shall be provided at no cost to the Owner.
- 2. Other Systems: Provide a minimum 2-year Manufacturer extended product, performance/application, and labor warranty UNLESS a different time period is provided within the specific specifications.
- C. The Manufacturer warranty period shall commence upon a Warranty Certificate being issued by the manufacturer. The Warranty Certificate shall be included with the O&M Manual submission. O&M Manual's submitted without the Manufacturer's Warranty Certificate will be rejected without review.

1.14 COORDINATION

- A. Thoroughly examine the Construction Documents, including Drawings and specification Sections of other Divisions, for construction details and methods that are dependent upon or will affect the work of other trades. The Contractor is responsible for identifying coordination issues and dependencies, and for preparing Shop Drawings, work plans and schedules to accommodate and/or mitigate coordination issues and dependencies before they arise.
- B. Changes necessitated by the failure of the Contractor to coordinate with the work of other trades shall be at no additional cost to the Owner.
- C. Confer and cooperate with the other trades, throughout the entire construction process, in order to coordinate the work in the proper sequence. Typical coordination issues include but are not limited to:
 - 1. Electrical work, including electrical receptacles, power panels, transformers, telecommunications grounding system, and the installation of raceway, device boxes, conduits, and sleeves for the Communications Cabling System.
 - 2. Mechanical work, including HVAC systems and ductwork, piping, and mechanical chases.
 - 3. Ceiling cavity spaces.
 - 4. Installation of acoustical ceiling tiles and similar finishes that may conceal the work.
 - 5. Build-in of oversized equipment during structure construction.
 - 6. Required separation distances.
 - 7. Access routes for equipment through the construction
 - 8. Cutting/coring of floor, ceiling or wall structures.

- D. Coordinate communications service installations with the Owner and with the Service Provider(s).
- E. Existing communications service outages shall be coordinated and scheduled in advance with the Owner at a time and duration acceptable to the Owner. Outages scheduled at times other than the normal working hours shall not entitle the Contractor to additional compensation beyond the original amount bid. Outages without advance notice and prior approval by the Owner are not acceptable.
- F. Review the Drawings and Specifications of other Divisions for locations of devices and equipment requiring communications connectivity not specified in this Division or shown on the Communications Drawings. Coordinate the locations of these items with the other trades, and shall verify locations with the Consultant and Owner prior to rough-in.
- G. Verify that the physical dimensions of each item of equipment fit the available space, promptly notify the Consultant of any potential conflicts, and await the Consultant's direction prior to purchase and rough-in of the equipment.
- H. Coordinate locations of devices, outlets, etc. with field conditions, unless such locations are specifically dimensioned or otherwise noted in the Construction Documents. If so noted, verify location with other affected trades and against existing field conditions, promptly notify the Consultant of any potential conflicts, and await the Consultant's direction prior to purchase and rough-in of the equipment.
- I. Coordinate locations for chases, slots, sleeves, and openings in the building structure. For new concrete coordinate, locate and provide chases, slots, sleeves, and openings prior to the pouring of the concrete.
- J. Coordinate communications installations' impact on code or manufacturer required access to equipment of other trades. Propose solutions to any conflicts prior to rough-in of communications equipment or support infrastructure.

1.15 RECORD DOCUMENTS

- A. Maintain a set of Record Documents showing all additions, changes, and deletions that have been made to the original Drawings and Specifications throughout the course of construction, as well as reviewed Submittal data.
- B. Items to be noted shall include but shall not be limited to:
 - 1. Routing of concealed raceways/pathways;
 - 2. Raceways/pathways located more than 2 feet from where shown on the original Contract Documents;
 - 3. Raceways and main pathways (pathways with more than 30 cables) not shown on the Contract Documents;
 - 4. Concealed equipment;
 - 5. Stub-outs; actual equipment locations, sizes and dimensions;
 - 6. Building outline changes;
 - 7. Addenda, accepted Alternates, Change Orders, other document revisions which occurred after the award of the Contract and/or the start of construction activities;
 - 8. System component labels and identifiers for all major components.

- C. Notations shall be handwritten in a neat and legible manner and shall be noted as follows:
 - 1. Red – for additions and changes
 - 2. Green – for deletions
 - 3. Blue – for notes
- D. The record drawings shall be submitted in accordance with the applicable portions of Section 017839 and as supplemented herein.

1.16 OPERATING AND MAINTENANCE (O&M) MANUALS

A. General:

- 1. O&M Manuals shall be submitted in accordance with the applicable portions of Section 017823 and as supplemented herein.
- 2. O&M Manuals shall be submitted as a single package and shall include subcontractor and vendor O&M information.
- 3. Catalog pages and data included in O&M Manuals shall be originals. Where not possible to obtain original copies in sufficient quantity, catalog pages and data shall be neat, clean copies of the originals.
- 4. O&M Manual Requirements: O&M Manuals shall include Product Data, Service, Spare Parts, Tests/Measurements/Calibration Settings, Record Drawings, Warranty information, and Other Information as required.
 - a. Product Data: Include the product data provided in the Submittal reflecting product as supplied and installed, as well as additional information such as installation, operation, and routine maintenance information.
 - b. Service: Assemble service information (cleaning, adjustments, frequency, etc.) for each device requiring service. For devices requiring qualified service, compile an index of qualified service providers (and their contact information) able to service these devices.
 - c. Spare Parts: Assemble a list of spare parts. Compile an index of spare parts providers (and their contact information) able to provide the spare parts.
 - d. Tests: Assemble all test documentation made for each system and/or device requiring testing.
 - e. Record Drawings: Provide Record Drawings per the requirements of Part 1 – General: Record Documents herein.
 - f. Warranty: Provide warranty documentation per the requirements of Part 1 – General: Warranty herein and the individual Specification Sections.
- 5. In addition, submit O&M Manuals in soft/electronic copy on a USB drive.

B. O&M Manual format:

- 1. Front cover of the O&M Manual shall indicate the name of the project, the project number, specification section the name of the Owner, year of completion, the title "Communications O&M Manual", and the names of the Contractor, as well as the General Contractor.
- 2. O&M Manual shall include the following sections, indexed (with tab dividers) accordingly.
 - a. Product Data
 - b. Service
 - c. Spare Parts

- d. Tests
 - e. Calibration/Configuration Settings
 - f. Record Drawings
 - g. Final Punchlist
 - h. Certificates of Inspection
 - i. Warranty:
 - 1) Contractor's Warranty Certificate
 - 2) Manufacturer's Warranty Certificate (as applicable)
 - j. Other Information (as applicable)
- 3. O&M Manuals shall include a table of contents identifying sections and page numbers.
 - 4. Pages within each section shall be numbered.
 - 5. Provide PDF format copies of all O&M Manuals
- C. O&M Manual submission:
- 1. The Contractor shall submit one draft copy of the O&M Manual for review and approval by the Consultant in PDF format
 - a. The submission will be reviewed for accuracy, completeness, and compliance to the requirements herein. A submission which fails to meet these requirements will be rejected and returned to the Contractor together with review comments and specific actions to be taken by the Contractor. The Contractor shall revise the O&M Manual and re-submit for review and approval.
 - b. The O&M Manual shall continue to be re-submitted and reviewed until such time as the O&M Manual is approved by the Consultant.
 - c. The Contractor shall be responsible for fees incurred by the Consultant resulting from subsequent review of O&M Manuals that fail to meet the requirements herein. Such fees will be incurred after the Consultant has reviewed the original submission and one re-submission.
 - 2. Upon approval of the draft copy, the Contractor shall submit final copies in quantities per the requirements of Section 017823.
 - 3. Final payment to the Contractor will not be authorized until the final copies of the O&M Manuals (including Record Documents) have been received and approved by the Consultant.

1.17 CONSULTING FEES

- A. The Specifications may identify work required of the Consultant due to various actions, lack of action, or deficiencies on the Contractor's part. Such instances will be identified in the individual Specification Sections (including this one) and the Contractor shall be responsible for these fees if they are incurred by the Consultant.
- B. Fees charged to the Contractor will be at the Consultant's billing rates at the time the services are performed. Travel time will be included, if applicable. Mileage will be charged for required automobile travel at the standard IRS mileage rate in effect at the time the services were performed. Expenses will be billed at cost plus 10% markup.

- C. Fees will either be paid directly to the Consultant or will be deducted directly from payments (or the final payment) to the Contractor.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Where products from several manufacturers are listed under a specified component:
 - 1. The products list shall be listed by manufacturer name
 - 2. Products not listed first shall be considered equal and there is no manufacturer preference of those listed as acceptable.
- B. If no product manufacturer is listed, then any manufacturer able to meet the listed specifications is acceptable.
- C. Where product is specified without the statement "or equal" and/or "or equivalent", substitutions will not be entertained.

2.2 MATERIALS

- A. The Contractor is responsible for providing all incidental and/or miscellaneous tools, scaffolding, consumable items, testing equipment appliances, and other hardware not explicitly specified or shown on the Drawings required for the installation of a complete and operable telecommunications infrastructure system ready for the Owner's use.
- B. Products shall be:
 - 1. New (except as otherwise indicated) and free from defects.
 - 2. Standard products of manufacturers regularly engaged in the production of such products.
 - 3. Of the manufacturer's latest standard design.
 - 4. Designed to ensure satisfactory operation and life in the environmental conditions that prevail in their installation location.
 - 5. For products of similar type, provide products manufactured by a single manufacturer.
 - 6. Where systems are indicated, provide component products manufactured by a single system manufacturer.
- C. Prior to ordering and delivery of equipment:
 - 1. Verify that the equipment shall adequately pass through building openings and passageways with unobstructed access to the final equipment location. When building openings and passageways will not permit the equipment to pass through unobstructed, equipment shall be manufactured and shipped in sections for final assembly at the equipment location. Submittals shall indicate sectionalized manufacturing of equipment.
 - 2. Verify that the equipment shall properly fit the space allocated, that required clearances can be maintained, and that the equipment can be located without interference from other systems, structural elements, or the work of other trades.

PART 3 - EXECUTION

3.1 GENERAL

- A. All contractor personnel shall be clearly identified by uniform and/or company badge with photo ID, employee's name, and company name. Contractor vehicles shall be equipped with signs on both sides of vehicle identifying the Contractor's company name.
- B. All Owner provided Contractor IDs shall be returned at or before project closeout.
- C. Installation shall be in a neat and workmanlike manner employing workers skilled in the trade, familiar with the particular techniques and methods of construction applicable to the work of the trade.
- D. Completed work shall present a neat and professionally installed appearance. The appearance of the work shall be of equal importance to its operation. Failure to present a neat and professionally installed appearance shall be considered sufficient reason for rejection of the system in part or in whole.
- E. Completed work shall demonstrate quality workmanship. Quality workmanship shall be of equal importance to its operation. Failure to demonstrate quality workmanship shall be considered sufficient reason for rejection of the system in part or in whole.
- F. Order and install materials and equipment with long lead times and/or those having a major impact on work by other trades so as not to jeopardize the project or project schedule.
- G. The Contractor is solely responsible for the safety of the public and workers in accordance with all applicable rules, regulations, building codes and ordinances, and Governmental Requirements, including but not limited to employee training and Safety Program development, documentation and execution.

3.2 PERMITS AND FEES

- A. Make arrangements to obtain and pay for necessary permits, licenses, and inspections.
- B. No work shall be started prior to obtaining necessary permits and payment of required fees. Work installed prior to obtaining proper permits shall, if required by the Governing Authority (AHJ), be redone in compliance with requirements at no additional cost to the Owner.

3.3 INSTALLATION

- A. Install product according to manufacturer recommendations, except where local codes or regulations take precedence.
- B. Installation shall comply with the applicable portions of the Governing Requirements (see Part 1 – General: Governing Requirements).

C. Dimensions and clearances:

1. Equipment dimensions and dimensions indicated for the installation of equipment are restrictive dimensions. Verify that the equipment will fit within the indicated locations and spaces.
2. Maintain, at a minimum, code required clearances.
3. Promptly notify the Consultant of any potential dimension or clearance conflicts, and await the Consultant's direction prior to purchase and rough-in of the equipment.

D. Access:

1. Install equipment such that it is readily accessible for operation and maintenance.
2. Access to equipment shall not be blocked or concealed by conduits, supporting devices, boxes, or other items.
3. Do not install equipment such that it interferes with the normal operation or maintenance requirements of other equipment.
4. Equipment shall be installed level, plumb, parallel, and perpendicular to building structures and to other building systems and components, except where otherwise indicated.
5. Equipment shall be securely fastened. Select fasteners so that the load applied to any one fastener does not exceed 25 percent of the proof-test load.
6. Place equipment labels and/or other identification where the label and/or identification can be easily seen and read without difficulty.

- E. Attachment of hanger rods, support cables, diagonal wall bracing, and any other connections made to the building structure after the fireproofing contractor has completed his work, shall be made with minimal impact to the existing fireproofing. The Contractor making such connections is responsible for (a) removal of firestopping where attachment is required and (b) scorings and over-cut as required for connection only. Contractor shall be held responsible for costs associated with the patch back of excessively removed firestopping material.

3.4 REFERENCES AND STANDARDS

- A. Work shall comply with the Governing Requirements listed in Governing Requirements herein.

3.5 SUPERVISION

- A. Appoint a Project Manager who will be the single point of contact for all work accomplished under this Project and will be vested by the Contractor with the authority to make decisions on behalf of the Contractor.
- B. The Project Manager will be responsible to represent the Contractor and coordinate all aspects of this Project, including but not limited to:
1. Overall and specific project responsibility.
 2. Thorough knowledge of Project Specifications and Drawings.
 3. Creation and maintenance of a project schedule, including milestones, task definitions and resource allocations.
 4. Attendance at all Project Management meetings.
 5. Supervision and direction of all Contractor personnel.

6. Documentation, including submittals and change orders.
 7. Quality assurance of Project.
- C. The Project Manager initially assigned to the Project shall be assigned to the Project for the duration of the Project. Once assigned by the Contractor, the Project Manager shall not be changed by the Contractor without Consultant and Owner approval.
- D. Assign a qualified Foreman to the Project and shall keep the Foremen on site and in charge of the work at all times. The Foreman shall be equipped with a mobile phone during project working hours.
- E. The Foreman initially assigned to the Project shall be assigned to the Project for the duration of the Project. Once assigned by the Contractor, the Foreman shall not be changed by the Contractor without Consultant and Owner approval.

3.6 DRAWINGS

- A. Drawings shall not be scaled for rough-in measurements or equipment locations. Field verification of dimensions, locations, and levels to suit field conditions is required. Final placement of devices, outlets, equipment, etc. shall be coordinated with field conditions.
- B. Unless specifically dimensioned or detailed, Drawings indicate approximate locations, arrangement, and general character. To avoid interference with structural members and equipment of other trades, or for the convenience of the Owner, it may be necessary to adjust the locations shown on the Drawings prior to installation. Unless specifically dimensioned or detailed, and with the exception of locations of equipment and raceway in Telecommunications Rooms, the Contractor may make minor location adjustments without obtaining the Consultant's prior approval. All other adjustments require prior approval from the Consultant.
- C. Minor adjustments are defined as distances not to exceed:
1. 1 foot at grade, floor ceiling, and roof level in any direction in the horizontal plane.
 2. 1 foot on walls in a horizontal direction within the vertical plane.
- D. Particular attention shall be paid to door swings, piping, ductwork, and structural steel:
1. In general, waste and vent lines, large pipe mains, and ductwork shall be given priority for the locations and spaces shown.
 2. In general, electrical lighting fixtures shall be given priority for ceiling space.
- E. Where minor location adjustments are required, such adjustments shall be made at no cost to the Owner.

3.7 PENETRATIONS, PATCHING, AND PAINTING

- A. Penetrations (openings, holes, chases, sleeves, slots, cuts, etc.):
1. Properly size and locate penetrations required as construction progresses. For new concrete or masonry the Contractor shall coordinate, locate and provide required openings prior to the pouring of concrete or construction of masonry.

2. Obtain written approval from the Structural Consultant/Architect for penetration of structural elements prior to penetration.
3. Penetration of concrete and structural elements shall be avoided where possible. Where not possible, penetrations shall be performed in a manner that will not reduce structural element load-carrying capacity or load-deflection ratio.
4. Penetrations shall be performed by workers qualified and skilled in the trades involved.
5. Penetrations shall not be exposed on the exterior or in occupied spaces in a manner that would, in the Consultant's opinion, reduce the aesthetic qualities of the structure or result in visual evidence of penetration and patching.
6. Penetrations shall be constructed using methods least likely to damage elements to be retained or adjoining construction.
 - a. Provide temporary support for the work to be penetrated.
 - b. In general, where cutting is required, use hand or small power tools designed for sawing or grinding, not for hammering or chopping. Cut holes and slots neatly to required size with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.
 - c. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring of existing finished surfaces.
 - d. Cut through concrete and masonry using a cutting device such as a Carborundum saw or diamond core drill.
7. Voids around penetrations shall be properly sealed, caulked or grouted as required.
8. Existing elements:
 - a. The Contractor shall be responsible for identifying, locating, and protecting existing embedded conduits, pipe, ductwork, etc. when penetrating existing structures.
 - b. Cap, valve, plug or seal remaining portions of cut pipes or conduit to prevent entrance of moisture or other foreign matter.
 - c. The Contractor shall be responsible for repairing and/or replacing existing conduits, pipe, ductwork, etc. damaged by the Contractor during construction of penetrations. Repair and/or replacement shall be at no additional cost to the Owner.
9. Penetrations (and subsequent patching) resulting from the Contractor's failure to properly coordinate penetrations shall be at no additional cost to the Owner.

B. Patching:

1. Patching in every instance consists of completing the work to match and blend with the adjoining existing work insofar as methods, materials, colors, and workmanship are concerned
2. Patching shall be performed by workers qualified and skilled in the trades involved.
3. The Contractor shall be responsible for replacing improperly matched, blended, or poorly constructed patches at no additional cost to the Owner.

C. Painting:

1. Painting shall consist of cleaning, surface preparation, painting (primer, intermediate, and finish) and finishing surfaces and items, new and existing, affected by the work of the Contractor.
 - a. Surface painting shall match and blend with existing adjoining surfaces.
 - b. Scratched, chipped, or otherwise marred equipment shall be repainted to match original finish.
 - c. The areas around penetrations, once sealed, shall be painted.
2. Painting shall be performed by workers qualified and skilled in the trades involved.
3. The Contractor shall be responsible for refinishing and repainting improperly matched, blended, or poorly painted surfaces and items at no additional cost to the Owner.

3.8 DEMOLITION

- A. Do not assume that all communications cabling and equipment within an area-to-be-demolished is to be demolished. Prior to start of demolition visit the site and survey the existing cabling and equipment. Track source and destination where possible and provide a submittal of items to be demolished or left in place for Owner review and written signoff.
- B. Provide a schedule of demolition activity to Owner prior to proceeding so that they may give users advance warning of any temporary interruption or change-over. Do not proceed without written approval from Owner.
- C. Comply with NFPA 70 requirements for removal or tagging existing communications cabling in areas to be demolished.
- D. Responsibility for support (in compliance with current codes) for cabling that is deemed existing-to-remain is the contractor's responsibility. Where conditions are not readily observable at time of bid (but deficiencies are found during survey after ceiling removal) provide pricing and obtain written approval for additional supports prior to proceeding.

3.9 HOUSEKEEPING

- A. General
 1. Comply with General Contractor and Owner requirements for site operations including work area cleaning and debris removal.
 2. See Section 27 1130 Construction Maintenance of Telecommunications Spaces for additional requirements.
- B. During the course of construction: At the conclusion of each day's work, remove empty boxes, crates, and other debris, and sweep clean all work areas affected by the Contractor's work of the day.

C. At project completion:

1. Remove all tools and scaffolding.
2. Equipment and facilities shall be thoroughly cleaned inside and out and residue removed.
3. Remove temporary labels and adhesives.
4. Thoroughly vacuum the interior of enclosures to remove debris.
5. Surplus product, materials and debris shall be cleared from the job site.
6. The Contractor is solely responsible for the appropriate disposal of all surplus product, materials and debris.

3.10 SUBSTANTIAL COMPLETION

A. Pre-Substantial Completion Submittal: Three weeks prior to Substantial Completion, the Contractor shall prepare and submit the following:

B. Known Exceptions/Deviations List:

1. A thorough list of known exceptions/deviations (in materials, construction, and/or workmanship) from that specified in the Contract Documents, and for which there was not associated documentation in the form of Change Orders (CO), Construction Change Directives (CCD), Architects Supplemental Instructions (ASI), or responses to a Request for Information (RFI).
2. The Contractor shall submit the list to the Consultant for review. The Consultant shall review each item and mark as either Accepted or Not Approved.
 - a. Items marked "Not Approved" shall be corrected by the Contractor to conform with the intent of the Contract Documents at no additional cost to the Owner.
 - b. Perform corrective action for "Not Approved" items prior to notifying the Consultant that the work is Substantially Complete.

C. Notice of Substantial Completion: When the Work nears Substantial Completion, notify the Consultant in writing the date that the work will be Substantially Complete and ready for review by the Consultant.

3.11 PROJECT CLOSE-OUT

A. Punchlist:

1. Once notice of Substantial Completion is received, the Consultant shall visit the site to review the Work, and shall prepare a punchlist of items determined to be incomplete, deficient or otherwise not in compliance with the intent of the Contract Documents.
2. During the review of the Work, if the Consultant finds that the Known Exceptions/Deviations List provided by the Contractor was insufficiently thorough, that the Work is not Substantially Complete, or that deficiencies in the work are excessive, the Consultant will cease review and inform the Contractor that the work is not Substantially Complete. The Contractor shall be responsible for fees incurred by the Consultant for this partial review.

3. Perform corrective action for each item noted in the punchlist. When complete, the Contractor shall submit the original punchlist with each item initialed attesting to the fact that the item was corrected. If necessary, the Consultant will perform a subsequent review after receipt of the Contractor initialed punchlist.
 4. Should additional reviews beyond the original punchlist review be required of the Consultant due to the Contractor's failure to correct all incomplete, deficient, or non-compliant work, the Contractor shall be responsible for fees incurred by the Consultant for the additional reviews.
- B. Provide O&M Manuals per the requirements of Part 1 – General: Operating & Maintenance (O&M) Manuals.

3.12 FOLLOW UP

- A. After the system(s) and facility have been placed in operation and are in use by the Owner, provide technical assistance for the first two weeks of operation on a standby basis for troubleshooting, education, and problem solving.

END OF SECTION

SECTION 27 05 28

COMMUNICATIONS ANCILLARY INFRASTRUCTURE (Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The requirements of Division 26 shall serve as the basis for the requirements of this Specification Section. The requirements of this Section are in addition to, different from, or otherwise supplement the requirements of Division 26. In case of conflict, the most stringent requirements shall apply (subject to the conflict resolution requirements in the Intent and Interpretations paragraphs of Section 27 0500 Common Work Results for Communications Systems).

1.2 SUMMARY

- A. This Section includes requirements for interior raceways, pathways, and grounding specific to supporting the communications infrastructure system.

1.3 GOVERNING REQUIREMENTS

- A. In addition to those requirements listed in Division 26 work shall comply with the references and standards listed in Section 27 0500 – Common Work Results for Communications Systems, Governing Requirements.

1.4 SUBMITTALS

- A. Provide submittal information for the following submittal sections as described below:
 - 1. Product Data
 - 2. Shop Drawings:
 - a. Raceway/Pathway Routing Plan: Provide only if routing has not been shown on the Drawings, or if the Contractor is proposing a deviation.
 - b. Cable tray: Detail fabrication and installation of cable tray, including plans, typical elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
- B. Routing: The Drawings indicate the general route of the raceway and cable tray system. Data presented on these Drawings is as accurate as preliminary planning can ascertain until final equipment selection is made. Exact routing, locations, distances and levels will be governed by actual field conditions. Verify exact routing, locations, distances, elevations, levels, dimensions, etc. prior to submitting coordination drawings

PART 2 - MATERIALS

2.1 GENERAL

- A. Products specified in this Section shall be UL Listed and Labeled.

2.2 BACKBOARDS

- A. Communications Equipment Room backboards shall have the following properties:
1. 3/4-inch fire retardant A-C plywood, void free
 2. 8' high unless otherwise noted,
 3. Capable of supporting attached equipment
 4. Painted with a minimum of two coats of light-colored semi-gloss paint.
 5. Width shall be as required to cover walls fully or as shown on drawings.

2.3 CONDUITS AND BOXES

- A. Conduit type definitions:
1. Electrical Metallic Tubing (EMT): EMT shall be steel, hot-dipped galvanized, or electro-galvanized, with an inner coating to protect cables and aid pulling, UL listed, and meeting the requirements of UL 797 and ANSI C80.3.
 2. Rigid Metal Conduit (RMC): RMC shall be steel, hot-dipped galvanized inside and outside with factory threaded ends galvanized after threading, UL listed, and meeting the requirements of UL 6 and ANSI C80.1.
 3. Rigid Nonmetallic Conduit (RNC): RNC shall be PVC Schedule 40 (unless otherwise noted) meeting the requirements of NEMA TC 2.
 4. Flexible (flex) conduit: Flex conduit is not approved and not acceptable.
- B. Conduit types to be used:
1. Provide EMT except as noted below or as shown on the Drawings
 2. Under slab/below grade, provide RNC. When using RNC, transition to and provide RMC for all bends and stub-up locations.
 3. Inside building above grade when extending non-indoor rated cables requiring grounding or primary protection or other conditions for extending National Electrical Code "Point of Service" location within building, provide RMC or IMC
 4. Embedded in concrete slabs (only in sizes and locations allowed by project structural standards):
 - a. At or below grade level: Provide RMC.
 - b. Above grade level: Provide EMT or RMC.
 - c. Through slab floors: Provide RMC.
 5. Through floor floors: Sleeves shall be provided with insulated throat bushings on each end. Provide RMC conduit.
 6. Hazardous areas: Provide RMC.

C. Conduit sleeves:

1. For sleeves through non-fire rated barriers/walls: Sleeves shall be EMT conduit and shall be complete with insulated throat bushings on each end. Sleeve type and size shall be according to the quantity of cable to pass through them per NEC fill ratios and the applicable ANSI/TIA standards with 25% spare capacity.

D. Condulets (LB's) are not acceptable.

E. Device boxes:

1. Device boxes shall be one piece (without welds or tab connections), with knockouts for conduit entrances, meeting NEMA OS 1, and with plaster/extension rings to suit construction and application.
2. Boxes shall be sized as shown on the Drawings.
3. Where multiple device boxes (including electrical) are grouped together, provide a rigid mounting bracket for precise alignment.
4. Product: Panduit PRBS16 or equivalent.

F. Pull Boxes:

1. Boxes shall be code gauge sheet metal/fabricated steel continuously welded at seams and painted after fabrication.
2. Boxes shall be complete with covers, trim, etc.
3. Conduits shall:
 - a. Only enter pull boxes from opposite ends.
 - b. Be sized appropriately for pulling cable.
 - c. Be no smaller than the 2014 NEC Article 314.28 or latest adopted code equivalent.

2.4 RATED PATHWAY ASSEMBLIES

A. Smoke Rated Pathways

1. The assembly shall be smoke rated with a built-in sealing system and shall automatically adjust to the installed cable loading and shall permit cables to be installed, removed, or retrofitted without the need to remove or reinstall acoustical materials.
2. The pathway shall provide an achievable STC rating of greater than or equal to the STC rating of the specific underlying construction per ASTM E90-04/ASTM C919.
3. The pathway shall be capable of maintaining its rating while allowing a 0 to 100 percent visual fill of cables.
4. Pathways shall be as shown on Drawings or of a sufficient size to accommodate the quantity and size of cables required.
5. Multiple pathways shall be installed with a gangable bracket to reduce the installation space.

B. Fire Rated Pathways

1. The assembly shall be fire rated with a built-in fire sealing system sufficient to maintain the hourly fire rating of the barrier being penetrated.

2. The self-contained sealing system shall automatically adjust to the installed cable loading and shall permit cables to be installed, removed, or retrofitted without the need to remove or reinstall firestop materials.
3. The pathway shall be capable of maintaining its rating while allowing a 0 to 100 percent visual fill of cables.
4. The pathway shall be UL Classified and/or FM Systems Approved and tested to the requirements of ASTM E814 (UL1479) & CAN/ULC-S115.
5. Pathways shall be as shown on Drawings or of a sufficient size to accommodate the quantity and size of cables required.
6. Multiple pathways shall be installed with a gangable bracket to reduce the installation space.

C. Manufacturers:

1. STI – Specified Technologies, Inc.

D. Products:

1. Through Wall Smoke Rated Pathways:
 - a. STI EZ-Path Series 33NEZ with NEZDP233 or NEZDP433 wall bracket
2. Through Wall Fire Rated Pathways:
 - a. STI EZ-Path Series 44+ with EYP544W wall bracket
 - b. STI EZ-Path Series 33 with EYP433W wall bracket
3. Through Floor Fire Rated Pathways:
 - a. 4-slot: STI EZ-Path Series 44+ with EYG444 floor bracket
 - b. 8-slot: STI EZ-Path Series 44+ with EYG844 floor bracket

2.5 INNERDUCTS

A. Innerducts shall have the following properties:

1. Color shall be orange
2. 1/4" diameter corrugated plastic or fabric multi-cell
3. Underground, plenum, or riser rated depending on environment.

B. Manufacturers:

1. Endot Industries Part No.: ENDOCOR/PL (Plenum), ENDOCOR/RI (Riser).
2. Carlon
3. MaxCell
4. Approved Equivalent

C. Products:

1. Carlon Resi-Gard
2. MaxCell xxxx

2.6 FLOOR BOXES AND POKE-THRUS

- A. Floor boxes and poke-thru devices may be combined with power where shown on the Drawings. When combined, provided metal dividers separating power from communications and provide separate conduits for power and communications.
- B. Floor boxes shall have the following properties
 - 1. Covers for floor boxes shall support carpet/floor trim to match surrounding floor area.
 - 2. Floor boxes shall be completed with matching pour boxes for installation in concrete slabs.
 - 3. See drawings for exact configurations
- C. Poke-thrus shall have the following properties:
 - 1. Recessed connections with cover.
 - 2. Appropriate attachments to allow conduit connections to provide continuous conduits to the ceiling of the floor it serves.
 - 3. Specific sections designated for power, data and AV cabling.
 - 4. For poke-thrus with AV, power, and data, size shall be 6" or 8" diameter.
- D. Manufacturers
 - 1. Legrand Wiremold
 - 2. Hubbell
 - 3. FSR
 - 4. Approved Equivalent
- E. Products
 - 1. Communications/Power Floor Boxes:
 - a. Wiremold RFB4E-OG series with specific attachments for furniture feed or outlets.
 - 2. Communications/Power Poke-thru
 - a. Poke-Thru for furniture: Wiremold 4FFATCBK
 - b. Poke-Thru with outlets: Wiremold 6ATCBK
 - 3. Communications/Audio-Visual/Power Floor Boxes
 - a. FSR-FL-500P-GRD series
 - b. AV Poke-thru - Wiremold 8ATCBK
 - 4. Communications/Audio-Visual/Power Poke-thrus
 - a. FSR-FL-500P-GRD series
 - b. Wiremold 8ATCBK

2.7 CABLE SUPPORTS

- A. Provide cable supports that meet and/or exceed the following requirements:
 - 1. Cable supports shall be complete with all incidental materials and assemblies required, including but not limited to mounting accessories to independently support supports from structure, extender brackets for mounting multiple hooks on a single support, clamps and fasteners, dedicated support wires, purlins and cable retainers as required.
 - 2. Wide-based j-hooks or saddles with flared edges, sized to accommodate cabling.
 - 3. Supports, incidental materials, and cable retainers shall be plenum rated if used in a plenum environment,
 - 4. UL 2239 listed, and shall have the manufacturer's name and part number stamped on the part for easy identification.
- B. Manufacturers:
 - 1. Arlington
 - 2. Erico CADDY
 - 3. Cooper B-Line
 - 4. CEAS
 - 5. Approved Equivalent
- C. Products:
 - 1. J-Hooks:
 - a. Erico CADDY CableCat Wide Base Cable Supports
 - b. CPI RapidTrak
 - c. Copper B-Line
 - 2. Straps/Slings/Saddles
 - a. Arlington
 - b. Erico CADDY CableCat Adjustable Cable Supports
 - c. Copper B-Line

2.8 FIRESTOPPING

- A. Putty:
 - 1. Firestopping putty used to seal open penetrations through which cable passes shall be re-usable/re-enterable.
 - 2. Provide through-penetration firestop products, fire-resistive joint system products, and perimeter fire containment system products that are compatible with one another, with the substrates forming openings, and with the items, if any, penetrating through-penetration firestop systems, under conditions of service and application, as demonstrated by firestopping products manufacturer based upon testing and field experience.

3. Provide firestop products that upon curing do not re-emulsify, dissolve, leach, breakdown or otherwise deteriorate over time from exposure to atmospheric moisture, sweating pipes, ponding water or other forms of moisture characteristic during and after construction.
 4. Provide firestop sealants sufficiently flexible to accommodate motion such as pipe vibration, water hammer, thermal expansion and other normal building movement without damage to the seal.
 5. All firestop products shall be UL Listed and Labeled.
- B. Material shall conform to both Flame (F) and Temperature (T) ratings as required by local building codes and as tested by nationally accepted test agencies per ASTM E814 or UL 1479 fire test in a configuration that is representative of the actual field conditions.
1. Materials shall be complete with necessary accessory materials, as applicable, for complete UL Listed and approved assemblies.
 2. Firestopping material shall be as specified in Division 7
- C. Conduit Plug:
1. Plugs shall be pre-made Intumescent seals sized to be 2" or 4" intended to firestop the end of conduits.
 2. STI: FP200 or FP400

2.9 GROUNDING AND BONDING

- A. Telecommunications grounding and bonding shall meet requirements of ANSI/TIA-607-D
- B. Ground Busbars: Grounding busbars shall meet the specifications of ANSI/TIA-607-D and conform to BICSI recommendations, with standard NEMA bolt hole sizing. Grounding busbars shall be plated for reduced contact resistance. All connections shall have 2-hole lugs.
1. Primary Bonding Busbar (PBB): Provide as shown on the Drawings. Where not shown, provide a minimum of one PBB per main telecommunications room (i.e. TEF or TER). Busbar shall be:
 - a. CPI: 40153-020 (20-inches x 4-inches)
 - b. Erico: TMGB-A20L27PT (20-inches x 4-inches)
 - c. Approved equivalent
 2. Secondary Bonding Busbar (SBB): Provide as shown on the Drawings. Where not shown, provide a minimum of one SBB per each Technology Distribution Room (or IDF box). For large TDRs requiring more grounding connections, increase SBB size to match PBB size. Busbar shall be, at a minimum:
 - a. CPI: 40153-012 (12-inches x 4-inches)
 - b. Erico: TMGB-A12L15PT (12-inches x 4-inches)
 - c. Approved equivalent

3. Rack Bonding Busbar (RBB): Provide an RBB for each metal enclosure including cabinets and racks. See Section 27 1100 Communications Equipment Room for specification.

C. Bonding Conductors:

1. Telecommunications Bonding Backbone (TBB): TBBs shall be solid copper conductor, unless stranded is required due to wire size and may be insulated (green). Unless otherwise noted on Drawings, TBB shall be sized according to conductor length based on ANSI/TIA-607-D Table 1.
2. Bonding Backbone (BBC): BBCs shall be solid copper conductor unless stranded is required due to wire size and may be insulated (green). Unless otherwise noted on Drawings, conductors shall be sized, at a minimum, the same size as the largest TBB to which it is connected.
3. Telecommunications Bonding Conductor (TBC): Provide a stranded copper conductor sized, at a minimum, the same size as the largest TBB from the PBB to the Electrical Entrance Facility bonding point. The TBB may be insulated (green).
4. Structural metal bonding conductors to the PBB or SBB shall be sized according to ANSI/TIA-607-D Table 1.

PART 3 - EXECUTION

3.1 GENERAL

- A. Work in this section is additional to, different from, or otherwise supplements the requirements of Division 26 Section. The requirements of Division 26 shall serve as the basis for the requirements of this Section.
- B. Part 1 – General: References and Standards herein.
 1. The Contractor shall pay particular attention to and comply with the following:
 - a. ANSI/TIA-569-E: Commercial Building Standard for Telecommunication Pathways and Spaces
 - b. ANSI/TIA-606-D: The Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
 - c. ANSI/TIA-607-D: Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
 - d. NEC: Comply with the NEC as applicable to construction and installation of cable tray and cable channel systems (Article 392, NEC).
 - e. NFPA: Comply with NFPA 70B, "Recommended Practice for Electrical Equipment Maintenance" pertaining to the installation of cable tray systems.
 2. Installation shall be such that communications circuits, when installed in the raceway system, are able to fully comply with the ANSI/TIA-568-Series: Commercial Building Telecommunications Cabling Standard.

3.2 BACKBOARDS

- A. Mount backboards on walls in locations shown on the Drawings with base of backboard at 12" A.F.F to a height of 108" A.F.F., with the "A" side exposed.

- B. Attach backboards to wall studs along the entire length of the wall. Backboards shall be smoothly sanded, sealed and painted with a minimum of two coats of non-conductive, light colored semi-gloss paint.
- C. Paint shall be compatible for adherence with backboard and shall not void the fire retardant rating. **Leave fire rating stamps unpainted.**

3.3 CONDUITS AND BOXES

- A. Conduit:
 - 1. Size conduits and other raceway as shown on the Drawings. Where not shown on the Drawings, size according to the amount of cable it is to support per NEC and ANSI/TIA-569-E cable capacity standards, plus an additional 50% for future expansion.
 - 2. Unless otherwise indicated here or on drawings, conduits installations shall comply with Division 26 requirements and shall have insulated throat bushings.
 - 3. Run conduit in the most direct route possible, parallel and perpendicular to building lines. Do not route conduit through areas in which flammable material may be stored, or over or adjacent to boilers, incinerators, hot water lines, or steam lines. Do not route conduit in areas not allowed by code such as stairways and elevator rooms.
 - 4. Conduit for station cabling: Total length of a given conduit run (from device box to telecommunications closet), including all intermediary conduits and pull boxes, shall not exceed 270 feet. Conduit runs shall contain no continuous sections longer than 150 feet. Provide intermediary pull boxes as necessary to comply with this requirement.
 - 5. Conduit bends:
 - a. A conduit bend shall not exceed 90 degrees.
 - 1) Conduit bends shall be sweeping, shall conform to ANSI/TIA-569-E bend radius requirements, and shall be a minimum of no less than 10 times the internal diameter of the conduit.
 - 2) For conduits larger than 1-½ inches, bends shall be factory-manufactured. Bending conduit larger than 1-½ inches in the field using manual or mechanical methods is not acceptable.
 - 3) The contractor shall test each conduit with a mandrel to prove compliance with the bend radius requirements throughout the conduit run and shall provide evidence of such testing immediately upon request of the Engineer.
 - b. The sum total of conduit bends for a conduit segment between end points/pull boxes shall not exceed 180 degrees, except as noted below:
 - 1) One additional bend of up to 90 degrees is acceptable if the bend is located within 12 inches of the cable feed end.
 - 2) The use of 90-degree condulets (LB's) for telecom cabling is not acceptable.
 - 6. Conduit Stubs: Install conduit stubs where called out on Drawings.
 - a. From device boxes in partition walls: Conduit stubs shall extend a minimum of 6-inches above top of partition wall and shall be angled 30 degrees toward the nearest raceway/pathway for station cabling.

- b. From device boxes, pull boxes, floor boxes, and/or poke-throughs to cable tray: Terminate conduits 2 to 4 vertical inches above the tray and within 2 horizontal inches of the edge of the tray. Conduits shall not extend over the edge of the cable tray.
 7. Ream conduits to eliminate sharp edges and terminate with metallic insulated throat bushings.
 8. Metallic conduits entering communication or equipment rooms shall be equipped with grounding lugs. Cap each conduit with a mechanical-type seal for protection.
 9. Equip all conduits over 3-feet long with a plastic or nylon pull string with a minimum test rating of 200 lb. Extend pull string a minimum of 3-feet from each end and securely tied in place.
 10. Terminate conduits that protrude through a floor 1 to 3 inches above the surface of the floor.
 11. Conduits entering through the floor of a telecommunications closet shall terminate 4 inches above the finished floor.
 12. When using RNC, transition to and provide RMC for all bends and stub-up locations.
 13. Minimum conduit size, where not shown on the Drawings, shall be 1".
- B. Device Boxes:
1. Unless otherwise indicated, boxes shall be recessed. Set device boxes plumb, level, square and flush with wall. Do not exceed more than 1/16 inch tolerance for each condition.
 2. Device boxes shall be located within 3-feet of an electrical receptacle. Where conditions are such that this is not possible, promptly notify the Engineer and await the Engineer's direction prior to rough-in of the device box.
 3. Where multiple device boxes (including electrical) are grouped together, provide a rigid mounting bracket for precise alignment.
 4. For acoustical purposes, device boxes on opposite sides of a wall shall not be located back-to-back.
- C. Pull Boxes: Install pull boxes in an exposed location, readily accessible both at time of construction and after building occupation. Pull boxes shall not be installed in interstitial or otherwise non-accessible building spaces.
1. If mounting pull box on ceiling structure above ceiling grid, do not mount higher than 4 feet above grid (mount on wall instead).
 2. Install pull boxes such that conduit enters and exits at opposite ends of the box. Conduit shall not enter pull boxes on the sides of the box (i.e. only 2 sides – at opposite ends – of the pull box may be used for conduit entry). Note that a pull box may not be substituted for a 90-degree bend.
 3. For conduit runs exceeding more than 100 feet in length, provide pull boxes so that no conduit segment between end points/pull boxes exceeds 100 feet.
 4. For conduit runs which require more than two 90 degree bends, install pull boxes so that no conduit segment between end points/pull boxes contains more than two 90 degree bends.
 5. Do not exceed one pull box per total conduit run between device box and termination point in a communications closet, unless otherwise shown on the Drawings, or approved by the Engineer.

3.4 FLOOR BOXES AND POKE-THRU DEVICES

- A. Set device boxes plumb, level, square and flush with floor. Boxes with square covers shall be installed parallel to walls. Do not exceed more than 1/16-inch tolerance for each condition. For floor boxes with combined power and communications circuits, install metal dividers for separation of circuits.
- B. Where boxes are installed in slab-on-grade, provide pan or box type rated for this application.
- C. Provide pour sleeves for poke-thru boxes to be installed in new post-tensioned slab structure. Where installed in existing post-tensioned slabs, provide x-ray or other approved methods to avoid damage to post-tension cable. Provide rebar scanning for all slab coring. Submit results for approval prior to coring.
- D. Where poke-thru devices require access from below, locate above accessible ceiling or provide approved access opening in inaccessible ceiling below. Do not locate poke-thrus above ductwork, piping or other construction rendering them functionally inaccessible.
- E. For poke-thrus, provide continuous conduit feeds from the poke-thru device up the nearest wall to the ceiling space of the floor that the poke-thru serves. See drawings and for additional routing.

3.5 RACEWAY

- A. Sleeves and pathways:
 - 1. Provide sleeves and pathways where required for cable passing through building structures, full height walls and rated barriers.
 - 2. Install sleeves and pathways at a height and location that does not require cabling to have a tight bending radius nor come in contact with obstructions.
 - 3. Install sleeves and pathways per manufacturer's recommendations.
 - 4. Ensure that a minimum of 12" clear is maintained in front of sleeves and pathways with no piping, duct, supports, or other obstructions.
 - 5. Where sleeves and pathways are used to extend cabling through walls from conduits or cable trays, ensure that no such obstructions exist in a direct line between conduit or cable tray regardless of distance.
 - 6. For sleeves constructed of conduit, seal between sleeve and building structure and/or barrier. Install insulated throat bushings before cable is installed.
- B. Cable Supports:
 - 1. Cable supports shall be used to support cables in open access environments. Supports shall be provided along the entire pathway. Multiple supports at hanger locations shall be provided as required by the quantity of cable to be supported (subject to the maximum load which can be supported by the hanger) as well as cable segregation requirements (see below).

2. Cable supports may be affixed to structural members and/or other supports, but shall not be attached to pipes, electrical conduit, mechanical items, existing cables, or the ceiling support system. Supports shall be hung from all thread rods, dedicated #8 galvanized ceiling drop wire, or from brackets connected directly to structure, and shall be installed above accessible ceilings.
3. Where cable pathways are shown on the Drawings, the Contractor shall follow the indicated pathways as closely as possible, subject to field conditions. Pathways for smaller cable counts shall be designed and documented on the As-Built drawings maintained by the Contractor. Supports shall be installed parallel and perpendicular to building lines.
4. Cable supports shall be mounted at varying intervals with each interval not to exceed 5 feet. Supports shall also be placed at all changes of direction. The Contractor shall ensure that intervals between cable supports shall vary along the pathway (i.e., a given interval should not be exactly the same length as the interval preceding or following it - "exact" intervals can degrade cable performance).
5. Cable supports shall not support more cables than for which they were designed and shall not exceed 50% of the manufacturer's recommended fill. Multiple cable supports shall be provided where the total cable fill exceeds this amount.
6. Installation of supports shall be fully coordinated with other elements such as mechanical ductwork, piping/plumbing, electrical conduit, and other systems such that the supports remain fully accessible after installation.

3.6 FIRESTOPPING

- A. Installation of firestops shall be in accordance with fire test reports, fire resistance requirements, acceptable sample installations, manufacturer's recommendations, local fire and building authorities, and the applicable portions of the Governing Requirements. Application of sealing material shall be accomplished in a manner acceptable to the local fire and building authorities.
- B. Installation shall be performed in strict accordance with manufacturer's detailed installation procedures.
 1. Prepare surfaces per manufacturer's instructions. After installation, clean all surfaces adjacent to sealed openings to be free of excess firestopping materials and soiling.
 2. Seal all openings or voids made by penetrations to ensure an air and water resistant seal.
 3. Consult with mechanical engineer, project manager, and damper manufacturer prior to installation of through-penetration firestop systems that might hamper the performance of fire dampers as it pertains to duct work.
 4. Protect materials from damage on surfaces subjected to traffic.
 5. Apply a suitable bond-breaker to prevent three-sided adhesion in applications where this condition might occur such as the intersection of a gypsum wallboard/steel stud wall to floor or roof assembly where the joint is backed by a steel ceiling runner or track.
 6. Where joint application is exposed to the elements, fire resistive joint sealant must be approved by manufacturer for use in exterior applications and shall comply with ASTM C-920.

- C. Penetrations through and membrane penetrations of fire rated barriers shall be firestopped and sealed. The fire rating of all penetrated fire barriers shall be strictly maintained.
- D. Install firestopping in open penetrations and in the annular space of penetrations for fire rated barriers.
- E. Do not install firestop products when ambient or substrate temperatures are outside limitations recommended by the manufacturer.
- F. Do not install firestop products when substrates are wet due to rain, frost, condensation or other causes.
- G. Do not use materials that contain flammable solvents or sodium silicate.
- H. Cables, conduits, and other raceway shall be firmly secured and cleaned where penetrating fire rated barriers. Firestopping devices shall not act as supports.

3.7 GROUNDING AND BONDING

- A. Grounding and bonding work shall comply with the National Electrical Code, UL 467, ANSI/TIA standards and the references and standards listed in Part 1 – References and Standards herein, as well as local codes which may specify additional grounding and/or bonding requirements.
- B. Primary Bonding Busbar (PBB)): Directly bond PBB to electrical service ground and to associated TBBs. Group protector, busbar bonding, and approved building grounding conductors toward the left, leaving space for equipment grounding conductors to the right.
- C. Secondary Bonding Busbar (SBB) Directly bond SBB to its associated TBB and to close building structural steel or other permanent metallic systems. Group protector, busbar bonding, and approved building grounding conductors toward the left, leaving space for equipment grounding conductors to the right.
- D. Telecommunications Bonding Backbone (TBB): TBBs shall be used to connect the PBB to each SBB. Route along the shortest and straightest path possible with minimal bends. Bends shall be sweeping. TBB's shall be continuous (without splices), and shall be insulated from their support.
- E. Backbone Bonding Conductor (BBC) BBCs shall be used to bond TBBs together in multi-story buildings. BBCs shall bond TBBs together on the top floor of the building, and at a minimum of every third floor in between the top floor and the first floor. Route along the shortest and straightest path possible with minimal bends. Bends shall be sweeping. BBCs shall be continuous (without splices), and shall be insulated from their support.

F. Bonding Conductor (BC):

1. BCs shall be used to bond all non-current carrying metal telecommunications equipment and materials to the nearest SBB. They shall also be used to bond the grounding busbar of a panelboard serving the room containing the SBB to the SBB. Route along the shortest and straightest path possible with minimal bends. Bends shall be sweeping. BCs shall be continuous (without splices), and shall be insulated from their support.
2. Ensure that bonding breaks through paint to bare metallic surface of all painted metallic hardware.

- G. Cable Tray: Provide a min. #6 bare ground cable the length of the cable tray. Bond to every tray section using clamps manufactured for that purpose. Ground cable shall be located on the outside of the cable tray.

END OF SECTION

SECTION 27 05 53

IDENTIFICATION FOR COMMUNICATIONS SYSTEMS (Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes requirements for communications the communications system identification.

1.2 SUBMITTALS

- A. Provide submittal information for the following submittal sections as described below:
 - 1. Provide a list of proposed hand-carried or computer software based identification/label makers, and a list of proposed materials for identifiers/labels.
 - 2. Provide actual samples of labels to be created for each system component to be labeled.

PART 2 - PRODUCTS

2.1 IDENTIFICATION

- A. Identifiers (labels) shall be as recommended in ANSI/TIA-606-D.
- B. Labels shall be permanent (i.e. not subject to fading or erasure) and permanently affixed. Handwritten labels as final identifying materials are not acceptable.
- C. For identification of materials and equipment interior to the facility:
 - 1. For cables: Labels shall be created by a hand-carried label maker or an equivalent computer/software-based label making system.
 - a. For station cables: Labels shall include a clear vinyl adhesive wrapping applied over the label in order to permanently affix the label to the cable. Using transparent tape to affix labels to cables is not acceptable.
 - b. For backbone cables: Labels shall be affixed or engraved on hard plastic markers.
 - 2. For equipment (racks, frames, cabinets, enclosures, etc.): Provide engraved nameplates.
- D. For identification of materials and equipment in the outside plant:
 - 1. Labels shall be waterproof (even when submerged) and engraved on hard plastic markers. Lettering shall be black, markers shall be white.

PART 3 - EXECUTION

3.1 GENERAL

- A. Work shall comply with the Governing Requirements as defined in Specification Section 270100 - Communications General Requirements. Governing Requirements of particular relevance to this Section include, but are not limited to ANSI/TIA-606-D: Administration Standard for Commercial Telecommunications Infrastructure
- B. See drawings for additional labeling requirements.
- C. The contractor is solely responsible for the completeness, accuracy, and placement of labels. Where questions arise regarding the correct label for a given component, notify the Owner and Consultant and await direction prior to proceeding.
- D. Install labels where indicated and at locations for best viewing convenience without interfering with the operation and maintenance of equipment.
- E. Coordinate names, abbreviations, colors, and other designations with the corresponding designations indicated in the Construction Documents and as required by codes and standards.
- F. Use consistent labels throughout the Project.
- G. Clean surfaces of dust, loose material, and oily films before applying self-adhesive labels.
- H. A minimum of two weeks prior to a particular component or group of components being labeled, review the proposed identification scheme, label(s), and procedure for affixing label(s) with the Owner and Consultant. Do not proceed with labeling until the Owner and Consultant have approved the proposed identification scheme, label(s), and procedure for affixing label(s).
- I. Physically verify that the component to be identified matches the label to be affixed, prior to affixing the label.

3.2 IDENTIFICATION AND LABELING

- A. Cable Type Designations shall be used for identification and labeling purposes, and shall be as follows:
 - 1. S: Station cable - copper (Category 6, 6A, etc. – inside plant only)
 - 2. SF: Station cable - fiber (typically multimode – inside plant only)
 - 3. SM: Single mode fiber backbone (inside and outside plant)
 - 4. MM: Multimode fiber backbone (inside and outside plant),
 - 5. H: Hybrid/composite single mode and multimode fiber backbone (inside and outside plant)
 - 6. C: Copper backbone used for voice grade communications (inside and outside plant)
 - 7. D: Copper backbone used for data grade communications (inside and outside plant)

3.3 COMPONENT IDENTIFICATION (LABELS):

- A. Telecommunications Rooms: Telecommunications Rooms shall be labeled as follows. In general, Telecommunications Rooms are labeled by floor and letter starting with the north. For example, the north Telecommunications Room on the first floor shall have the label "1A." The next moving towards the south will be "1B" and so forth.
- B. Equipment Racks, Frames, Cabinets, Enclosures, etc.: Equipment shall be labeled sequentially within a given room and as shown on the Drawings. Labels shall be of the form "XY" where "X" stands for "(R)ack", "(F)rame", "(C)abinet", or "(E)nclosure" and "Y" is the sequential equipment number within a given closet. For example: The first rack in a given Telecommunications Room would have the label "R1", the second "R2" and so on.
- C. Workstation outlet locations: See drawing details for labeling.
- D. Cables:
 - 1. Label Location: Affix labels at each end of the cable.
 - 2. Station Cables: Station cables shall be labeled with the same label as the patch panel port to which the station cable is connected in the Telecommunications Room.
 - 3. Backbone Cables: Cables shall be labeled sequentially by number, for each backbone Cable Type within the building. Labels at each end of the cable shall identify the Telecomm Room at the "far end" of the cable, and shall identify the sequential number of the cable, by Cable Type, within the building, separated by a dash (" - "). For example, the label on the near end of the fourth multimode fiber cable (within the building) with a far end terminating in Telecommunications Room 2A shall have the label "2A-MM4."
- E. Patch Panels:
 - 1. General: Patch panels shall be labeled sequentially within a Telecommunications Room, top to bottom, left to right, preceded with a "P" For example, the 4th copper patch panel shall have the label "P4."
 - 2. Backbone distribution patch panels:
 - a. Cable identification: Each patch panel used to terminate backbone cables shall identify the backbone cable(s) which terminate within it, using the "far end" label for the backbone cable. For patch panels which terminate multiple backbone cables, the ports associated with a given cable shall be identified.
 - b. Ports: Ports shall be labeled sequentially by port number for a given backbone cable. Port labels shall restart at "01" for each backbone cable within a panel. Ports shall be clearly identified as belonging to a particular backbone cable.

3. Components Specific to Fiber Patch Panels:
 - a. Connector Panels/Adapter Plates: Connector panels are typically pre-labeled by the manufacturer with labels such as "A", "B", etc. or "1", "2", etc. For connector panels which are not pre-labeled, connector panel labels shall be of the form "X" where "X" is an alphabetical letter identifying the sequential connector panel within the patch panel.

3.4 STATION (OUTLET) REFERENCE SPREADSHEET

- A. A Station (outlet) Reference Spreadsheet shall be maintained throughout construction. This spreadsheet shows, among other information, station labels, equipment rack designations, patch panel and port designations, and is intended for the Owner's use for patching and cross-connecting purposes during move-in.
- B. Maintain the electronic copy of the spreadsheet with up-to-date as-built information on a minimum two week interval throughout construction.
- C. Provide the Owner and/or Consultant an electronic copy of the up-to-date spreadsheet upon request during the course of construction.
- D. Three weeks prior to the scheduled move-in date, submit the final version of the spreadsheet to the Owner and Consultant. The final version of the spreadsheet shall incorporate all as-built information and any changes from the original Drawings.
- E. The contractor shall be solely responsible for the completeness and accuracy of the spreadsheet throughout construction and upon delivery to the Owner and Consultant.

END OF SECTION

SECTION 27 11 00

COMMUNICATIONS EQUIPMENT ROOM FITTINGS (Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes requirements for providing equipment and materials for TIA compliant technology rooms, equipment rooms, and entrance facilities.

1.2 SUBMITTALS

- A. Provide submittal information for the following submittal sections as described below:
 - 1. Product Data
 - 2. Shop Drawings:
 - a. Wall Field Termination Block and Wire Management Elevations: Provide only if elevations have not been shown on the Drawings, or if the Contractor is proposing a deviation.

PART 2 - PRODUCTS

2.1 ENTRANCE PROTECTION

- A. Provide primary protectors in accordance with NFPA 70 Article 800.
- B. Service entrance protectors:
 - 1. Protection panels fully enclosed with hinged doors
 - 2. 110 style input and output terminals
 - 3. Complying with UL 497 Primary Protection Standards
 - 4. Solid state 5-pin protection modules appropriate to circuit type
 - 5. Circa #1880ECA1-*** or approved equal
- C. Other cable protectors:
 - 1. Provide protectors complying with NFPA 70 and UL 497 fully compatible with Coaxial, Category 6, Category 6A, and PoE functionality.

2.2 CABLE MANAGEMENT UNITS

- A. Horizontal Managers shall have the following properties:
 - 1. 1 RMU, 2 RMU or 4 RMU as indicated on the Drawings.
 - 2. Single-sided, 19" wide
 - 3. Removable cover

B. Vertical Managers shall have the following properties:

1. 3", 6", or 10" wide as indicated on the Drawings
2. 7' tall to match the height of the equipment rack.
3. 19" wide, double sided.
4. 10" deep on both sides
5. Removable covers
6. Slack spools

C. Manufacturers:

1. Panduit
2. CPI
3. Hoffman
4. Approved Equivalent

D. Products:

1. Horizontal Manager: Panduit WMPSE
2. Vertical Manager: Panduit PR2VD08

2.3 EQUIPMENT RACKS

A. 19-Inch Equipment Racks

1. Description: Two post racks with threaded rails designed for mounting telecommunications equipment. Width is compatible with EIA/ECIA 310-E, 19-inch equipment mounting with an opening of 17.72-inches between rails.
2. General Requirements:
 - a. Frames: Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - b. Material: Steel.
 - c. Finish: Manufacturer's standard.
 - d. Color: Black.
 - e. Overall Height: 84 inches
 - f. Overall Depth: 18 inches
 - g. Upright Depth: 6 inches
 - h. Two-Post Load Rating: 1500 lbs.
 - i. Number of Rack Units per Rack: 45.
 - j. Numbering: Every rack units, on interior of rack.
 - k. Threads: 12-24.
 - l. Base shall have a minimum of four mounting holes for permanent attachment to floor.
 - m. Top shall have provisions for attaching to cable tray or ceiling.
3. Manufacturer: Panduit, Model: R2P6S.

2.4 EQUIPMENT CABINETS

- A. Description: Manufacturer-assembled four-post frame enclosed by side and top panels and front and rear doors, designed for mounting telecommunications equipment. Width is compatible with 19-inch equipment mounting.

B. General Cabinet Requirements:

1. Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
2. Material: steel.
3. Finish: Manufacturer's standard, baked-polyester powder coat.
4. Color: Black.
5. Dimensions: 23.62" W x 42.13" D x 79.39" T
6. Load Rating: 3000 lbs. min.
7. Number of Rack Units: 42, with every rack unit numbered.
8. Threads: 12-24.
9. Removable and lockable side and top panels.
10. Hinged and lockable front and rear doors.
11. Adjustable feet for leveling.
12. Screened ventilation openings in front and rear door.
13. Cable access provisions in roof and base.
14. All cabinets keyed alike.
15. Manufacturer: APC NetShelter SX Part No. AR3350.

2.5 GROUNDING FOR CABINETS AND RACKS

- A. Provide RBB groundbus and tin plated connectors for each cabinet or rack indicated on the drawings. RBB shall comply with the EIA universal mounting hole spacing and mount to standard racks and cabinets
1. All components shall be bonded to the rails with paint piercing hardware.
 2. Equipment shall be bonded to the RBB with a jumper and compression lugs.
 3. Provide all the necessary parts and grounding cable interconnects for a complete grounding system in compliance with ANSI/TIA-607-D.
- B. Manufacturer:
1. Panduit
 2. Approved Equivalent
- C. Product:
1. RBB Groundbus: RGRBN19 series

2.6 D-RINGS AND LADDER RACK

- A. D-Rings:
1. To route cables on backboards in telecommunications rooms. Size shall be a minimum of 2 inches in diameter.
 2. D-Rings shall be:
 - a. CPI: Composite: CPI 12127, 10812
 - b. CPI: Metallic: CPI 10941, 10942, 10943
 - c. Approved Equal

B. Ladder Rack:

1. Rack shall be complete with same finish fittings including but not limited to splice kits, cable radius drop-outs, radius bends, protective end caps, support brackets, foot kits, vertical wall brackets, wall angles, grounding hardware and other incidental and miscellaneous hardware required for a complete system.
 - a. Finish shall be black
 - b. UL listed for equipment ground
 - c. CPI: 10250 series
2. The 90 degree Horizontal Radius Bends shall be provided for each 90 degree change in direction of cable runway angle as shown on Drawings:
 - a. CPI: 10822 series
3. Cable Radius Drops shall be provided wherever cable is to drop from one section of cable runway to another lower section of cable runway, or is to drop from cable runway to equipment racks/frames:
 - a. CPI: 12100 series
4. Ladder Rack Grounding kits shall be provided across cable runway:
 - a. CPI: 40164 series
5. Channel Rack-To-Ladder Rack: Mounting Plate: Provide to secure ladder rack to equipment racks and frames. Provide for each equipment rack and/or equipment frame shown on the drawings. Mounting plates shall be mounted either parallel or perpendicular, depending upon the orientation of the ladder rack:
 - a. CPI: 10595 series
6. Ladder Rack Elevation Kit: Mount between rack mounting plate and ladder rack for connection to elevated ladder rack:
 - a. CPI: 10506 series

2.7 POWER PROTECTION AND POWER STRIPS

A. Requirements:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Vertically mounted and can be placed in both an equipment rack and equipment cabinet.
3. Input: NEMA L6-30P
4. Output: (20) IEC 60320 C13 and (4) IEC 60320 C19 receptacles.
5. LED indicator lights for power and protection status.
6. LED indicator lights for reverse polarity and open outlet ground.
7. Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
8. Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.

9. Cord connected with 10-foot line cord.
10. Rocker-type on-off switch, illuminated when in on position.

B. Manufacturers:

1. APC Part No. AP7541
2. Or approved equal.

PART 3 - EXECUTION

3.1 GENERAL

A. Equipment and installation shall strictly conform to requirements of the following:

1. ANSI/TIA-568 Series: Commercial Building Telecommunications Cabling Standard
2. ANSI/TIA-569-E: Commercial Building Standard for Telecommunications Pathways and Spaces
3. ANSI/TIA-606-D: Administration Standard for Commercial Telecommunications Infrastructure
4. ANSI/TIA-607-D: Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
5. ANSI/TIA-758-B: Customer-Owned Outside Plant Telecommunications Infrastructure Standard

3.2 ENTRANCE PROTECTION

- A. Provide primary protectors for all copper circuits entering/exiting building in accordance with NFPA 70 Article 800 and additional circuits where indicated on the drawings.

3.3 CABINETS, RACKS, FRAMES, AND ENCLOSURES

A. General

1. Furnish and install equipment complete with all required incidental hardware and materials.
2. Furnish and install equipment racks, frames, and enclosures in such a fashion to meet local code for seismic bracing requirements.
3. Bond each rack and cabinet to the grounding system.

B. Floor Mounted Equipment Racks:

1. Unless otherwise noted, furnish and install all equipment racks and associated cable management shall be provided by the contractor.
2. Refer to drawings for quantity of racks to be provided.
3. Refer to drawings for layouts and cable termination requirements.
4. For additional stability, affix and bolt the top of each equipment rack to the overhead ladder rack.
5. Bolt each equipment rack to floor using a minimum of four anchors.

6. When installing vertical cable management between racks, install management trough such that the management trough is as far back as possible between the racks.
7. When installing multiple equipment racks, bolt vertical cable management to each adjacent rack per manufacturer's instructions.

C. Cabinets

1. Unless otherwise noted, all network and server cabinets and associated cable management shall be provided by the contractor.
2. Refer to drawings for quantity of cabinets to be provided.
3. Refer to drawings for layouts and cable termination requirements.
4. Prior to installation, tape off areas on floor to show exact placement of racks/cabinets and to coordinate grommet locations if applicable.
5. Coordinate with the electrical contractor for exact placement of overhead bus duct or power outlets in relation to ladder trays and cabinets. Refer to installation details for requirements.
6. Securely bolt new cabinets to slab. Refer to installation details for requirements.
7. Provide patch panels and wire management on racks as shown on attached drawings.
8. Coordinate with the electrical contractor for connection of all cabinet mounted power strips.

3.4 CABLE MANAGEMENT AND LADDER RACK

A. Cable Management

1. C-Rings: Mount at 6-inch intervals and as shown on the Drawings
2. D-Rings: Mount at 12-inch intervals and as shown on the Drawings

B. Ladder Rack:

1. Install:
 - a. Per manufacturer's instructions with flat (rung) side up.
 - b. As indicated on the drawings with ends of ladder rack cut square, unless noted otherwise.
2. Ream cut ends to remove burrs and sharp edges.
3. Cap cut ends with manufacturer's recommended caps.
4. Provide cable radius drop outs as required.
5. Meet local code for seismic bracing.

END OF SECTION

SECTION 27 15 00

COMMUNICATIONS HORIZONTAL CABLING

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes requirements for the installation of a ANSI/TIA standard interior (inside plant) communications horizontal cabling system.

1.2 SUBMITTALS

- A. Provide submittal information for the following submittal sections as described below:
 - 1. Product Data: for all items to be provided and installed
 - 2. Cable Routing and Grouping Plan: Provide only if cable routing and grouping have not been shown on the Drawings, or if proposing a deviation.
 - 3. Testing Plan:
 - a. Provide a list of proposed test equipment for use in verifying the installation of the communications cabling system. Provide the following for each testing device:
 - 1) Manufacturer and product number.
 - 2) Manufacturer documentation showing date and outcome of last re-calibration. Testing device shall have been re-calibrated within the manufacturer's recommended recalibration period.
 - 3) Manufacturer documentation showing software revision. Software revision shall be most current revision available for the device and shall be based upon the most current ANSI/TIA testing guidelines.
 - 4) Patch cords and other specialized components.
 - b. Provide proposed test result forms.

PART 2 - PRODUCTS

2.1 SUBSTITUTIONS

- A. In general, product substitutions are not permitted.
- B. The owner reserves the right to disqualify any Contractor who offers structured cabling products other than those specified herein.
- C. The contractor shall be responsible and shall assume all costs for removal and replacement of any substituted materials installed without approval. Such costs shall include, but not be limited to labor, materials as well as any penalties, fees or costs incurred for late completion.

2.2 PERFORMANCE

A. Protocols/Services:

1. At a minimum, the communications cabling system shall support data network protocols/services at rates up to 1 Gbps using Category 6 cabling, and 10 Gbps for fiber stations. It shall support 10Mb, 100Mb, and 1Gb Ethernet and other network protocols. The communications cabling system shall additionally support RS-232 and other dedicated point-to-point protocols.
2. The communications cabling system shall support PBX and VoIP telephone services. It shall support analog, digital, ISDN, and VoIP services, and shall be compatible with direct trunk lines (POTS).

B. Category Rating (for copper components):

1. Copper components (cable, connectors, etc.) shall exceed the transmission requirements for what it is rated. Copper components shall be rated to meet or exceed the requirements for Category 6 or 6A cabling where indicated or greater.

2.3 CABLE

A. Cable shall have the following properties:

1. Meet or exceed transmission requirements as specified in ANSI/TIA-568.2-D.
 - a. Category 6 for typical outlets.
 - b. Category 6A for wireless access points.
2. Plenum (CMP) rated.
3. Color shall be blue or as indicated on drawings.
4. Cable installed in raceway below grade, in slab on grade or extending to the building from the exterior shall be indoor/outdoor with dry blocking and shall have the same indoor environment rating as the remainder of cabling in the facility.
5. Cable shall bear markings for the environment in which they are installed.

B. Products:

1. Category 6 cable: General Part No. 7131800
2. Category 6a cable: General Part No. 7141819

2.4 COAXIAL CABLE

A. Specifications:

1. RG-6 grade.
2. Solid conductor, 18-AWG.
3. Quad Shield.
4. Commscope Part No. 2227V.
5. Connectors: Belden SNS6 Series for Quad-Shield RG-6 cable.

2.5 TWISTED PAIR CABLE HARDWARE

- A. Manufacturer for all Copper Termination Hardware is Hubbell.
- B. UTP Patch Panels shall have the following properties:
 - 1. Flat and rack mountable in 19" rack
 - 2. 1 RU, 24-port, or 2 RU, 48-port
 - 3. Terminate 4-pair, 22-26 AWG, 100-ohm unshielded twisted pair cable with a standard 110 punchdown tool.
 - 4. IDC connectors to support a universal (T568A and T568B) wiring pattern.
 - 5. Rear cable support bar/strain relief (1 for 24-port patch panel, and 2 for 48-port patch panel)
 - 6. Exceed the transmission requirements for connecting hardware as specified in the ANSI/TIA standards for the Category for which they are rated and shall be complete with cable management for supporting cables behind the patch panel and with all incidental materials necessary for installation.
- C. Products:
 - 1. 24-Port, Category 6: HP624.
 - 2. 48-Port, Category 6: HP648.
 - 3. 24-Port, Category 6a: HPJ6A24.

2.6 CONNECTORS

- A. Horizontal Copper Connectors shall have the following properties:
 - 1. 8-position/8-conductor (8P/8C) UTP jack module
 - 2. Terminate 4-pair, 22-26 AWG, 100 ohm unshielded twisted pair cable with a standard 110 punchdown tool.
 - 3. Support a universal (T568A and T568B) wiring pattern.
 - 4. Shall exceed the transmission requirements for connecting hardware as specified in the ANSI/TIA standards for the Category for which they are rated
 - a. Category 6 for typical outlets.
 - b. Category 6A for wireless access points.
 - c. F81 for RG-6 coax locations.
 - 5. Color as indicated on Products section or on drawings.
 - 6. Manufacturer: Hubbell.
- B. Products:
 - 1. Category 6, Blue: HJU6B.
 - 2. Category 6, White: HJU6W.
 - 3. Category 6A, Blue: HJU6AB
 - 4. F81 Insert, Black: NSF70BK.

2.7 WORK AREA OUTLETS

- A. The work area outlets shall be configured as detailed below for each type. The color cable associated with the outlets are specified under the station cable section.
1. Universal Data Outlet:
 - a. 2-port faceplate
 - b. Color: White, or approved by the architect.
 - c. UTP cables(s) and connector(s), quantity as shown on drawings
 2. Wall Phone Outlet:
 - a. 1-port faceplate with two mounting studs
 - b. Stainless Steel
 - c. UTP cable and connector
 - d. Wall Phone Bracket furnished by Owner, installed by Contractor
 3. TV Outlet:
 - a. 4-port faceplate
 - b. Color: White, or approved by the architect.
 - c. UTP cable(s) and connector(s), quantity as shown on drawings
 - d. F-Connector insert and coax cable (where indicated)
 - e. RG6 Quad Shielded (RG6Q) station cable.
 4. Outlets for Wireless Access Point, Above Ceiling, and Security Camera Locations:
 - a. 2-port Surface Mount Box suitable for installation in air handling spaces
 - b. Color: White, or approved by the architect.
 - c. UTP cables and connectors
 5. Poke-Thru/Floor Box Outlets
 - a. UTP cables(s) and connector(s), quantity as shown on drawings
 - b. Provide faceplates and fittings as required for mounting connectors inside poke-thru and floor box devices. Faceplates and fittings shall be coordinated with and shall be manufactured by or approved for use by the manufacturer.
 6. Provide blank inserts for unused ports.
- B. Products
1. Faceplates:
 - a. Two Port: IFP12W.
 - b. Four Port: IFP14W.
 2. Surface Mount Box, 2 port: HSB2W.
 3. Wall Phone: Part No. SP6R

2.8 PATCH CORDS

- A. Coordinate exact lengths and colors prior to orderings with the owner. The details listed below are for pricing purposes.
- B. Patch Cords shall have the following properties:
 - 1. Factory manufactured, solid or stranded UTP, with 8-pin modular plugs.
 - 2. Manufactured by the selected communications cabling Manufacturer.
 - 3. Exceed Category 6 and Category 6A transmission as specified in ANSI/TIA-568 Series.
- C. Quantities:
 - 1. Provide patch cords at both ends (patch panel and work area).
 - 2. Provide patch cords for 70% of installed cables, one on each end.
- D. Colors and sizes shall be:
 - 1. Provide 10' patch cords for Work Area end.
 - 2. Provide 7' patch cords for Server Room end.
 - 3. Typical patch cord color shall be blue.
- E. Products:
 - 1. Category 6 UTP: Part No: HC6BXX, where XX equals length.
 - 2. Category 6A UTP: Part No. HC6BXXSP, where XX equals length.

2.9 CABLE SUPPORTS

- A. Provide per Division 27 Section 270528 – Communications Ancillary Infrastructure.

2.10 CABLE STRAPS

- A. Cable straps shall have the following properties:
 - 1. Self-gripping, reusable, constructed of Velcro, and hook-and-loop style.
 - 2. Cable straps to be used in plenum air handling spaces shall be plenum rated.
 - 3. Cable straps to be used within rooms shall be riser rated.
 - 4. Plastic tie wraps are unacceptable.

PART 3 - EXECUTION

3.1 GENERAL

A. Pay particular attention to and comply with the applicable portions of the following:

1. ANSI/TIA-568 Series: Commercial Building Telecommunications Cabling Standard
2. ANSI/TIA-569-E: Commercial Building Standard for Telecommunications Pathways and Spaces
3. ANSI/TIA-606-D: Administration Standard for Commercial Telecommunications Infrastructure
4. ANSI/TIA-607-D: Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
5. IEEE 802.3 Series: Local Area Network Ethernet Standard, including the IEEE 802.3z Gigabit and 802.3ae and 802.3an 10 Gigabit Ethernet Standard
6. BICSI: BICSI Telecommunications Cabling Installation Manual
7. Manufacturer Recommendations and Installation Guidelines

3.2 PATCH PANELS

A. Patch panel ports shall be terminated sequentially from left to right, from patch panel to patch panel.

3.3 CONNECTOR TERMINATION

A. The T568B wiring pattern shall be used for cable termination at both ends.

3.4 CABLE

A. General (applicable to all cable types):

1. Cable shall be installed in strict compliance with the manufacturer's recommendations.
2. Maintain separation from other conductors (power, fire alarm, etc.) per NEC requirements and ANSI/TIA standards.
3. The bending radius and pull strength requirements of all cable as detailed in the ANSI/TIA standards and the manufacturer's installation recommendations shall be strictly observed during handling and installation.
 - a. Pull cables simultaneously where more than one cable is being installed in the same raceway.
 - b. Use pulling compound or lubricant where necessary. Use compounds that will not damage conductor or insulation (Polywater, or approved equal).
 - c. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cable or raceway.
4. Do not twist cable jacket during installation. Cables showing evidence of twisting shall be replaced at no additional cost to the Owner, regardless of the outcome of cable testing.
5. Cable shall be installed in a continuous (non-spliced) manner unless otherwise indicated.

6. Cable installed in conduit and/or ducts:
 - a. Fill ratios shall not exceed NEC requirements.
 - b. Cable shall not be pulled into conduit/ducts until the conduit/duct ends have been prepared for cable installation (i.e. reamed to eliminate sharp edges and insulated throat bushings installed). Cables pulled into conduit/ducts prior to conduit/duct end preparation shall be replaced at no additional cost to the Owner.
 - c. Provide and install pull-wires in conduits and ducts after use to facilitate future addition of cables.
7. Cable installed in cable tray:
 - a. Cable shall not be attached to the cable tray (i.e. cable shall be left "loose") with the exception of cable installed in cable tray (cable runway) within telecommunications rooms (see "Cable in telecommunications rooms" below).
 - b. For performance reasons, station cable in tray shall not be combed.
 - c. Cable shall be laid in tray in such a way as to present a neat and professional appearance.
 - d. For cable tray serving both backbone (riser) and horizontal cabling, install cable in cable tray in such a manner that backbone cabling does not overlap with horizontal cabling – reserve approximately one-fourth of the space in the tray for backbone cabling and the remaining three-fourths for horizontal cabling.
 - e. Where cables in cable trays are required to maintain specific distances between each other they shall be firmly secured to maintain this distance at fire rated penetrations.
8. Cable not installed in conduit/ducts or cable tray:
 - a. Cables shall be strapped or fastened with reusable Velcro hook and loop style cable straps/fasteners for support. Staples and tie-wraps are not acceptable:
 - 1) Straps and fasteners shall not be over-tightened. Cables showing evidence of over-tightening shall be replaced at no additional cost to the Owner, regardless of the outcome of cable testing.
 - 2) Straps and fasteners installed in plenum spaces shall be plenum rated.
 - 3) Cables shall be bundled by application (horizontal or backbone) and by cable type (Category 3, Category 5, Category 5E, Category 6, Category 6A, MM Fiber, SM Fiber, etc.). Cable applications and types shall not be intermixed within a bundle.
 - b. Cables in suspended cable runs shall be supported by cable supports at varying intervals. Cable spans shall be limited to 5 feet or less, and the length of spans shall vary along the cable path (i.e. a given span should not be exactly the same length as the span preceding or following it – "exact" spans can degrade cable performance). See Division 27 Section 270528 – Communications Raceways and Pathways for requirements.
 - c. Cable installed on exposed surfaces or structural members shall be installed parallel and perpendicular to the surfaces. Surface contours shall be followed wherever possible. Cables shall be attached to surfaces at intervals not to exceed 3 feet.

- d. Attaching cables to pipes, electrical conduit, mechanical items, existing cables, or the ceiling support system (grids, hanger wires, etc. – with the exception of ceiling support anchors) is not acceptable.

9. Cable in Telecommunications Rooms:

a. Cable Straps

- 1) Install reusable Velcro hook-and-loop style straps to secure cable bundles (see below) to ladder rack and other supporting equipment. The use of plastic tie wraps for this purpose is not acceptable.
- 2) Bundling:
 - a) Cables shall be bundled by application (patch, horizontal, backbone) and by cable type (Category 3, Category 5E, Category 6, Category 6A, MM Fiber, SM Fiber, etc.). Cable applications and types shall not be intermixed within a bundle.
 - b) Cable bundles (of a given application and cable type) shall be even cable quantity.
- 3) Provide excess cable straps to Owner.
- 4) Station cables in suspended cable runs shall be supported at varying intervals. Cable spans shall be limited to 5-feet or less, and the length of spans shall vary along the cable path (i.e., a given span should not be exactly the same length as the span preceding or following it, as "exact" spans can degrade cable performance).

b. Cable on backboards:

- 1) Lay and dress all cables to allow other cables to enter raceway (conduit or otherwise) without difficulty at a later time by maintaining a working distance from these openings.
- 2) Cable shall be routed as close as possible to the ceiling, floor, sides, or corners to insure that adequate wall or backboard space is available for current and future equipment and for cable terminations.
- 3) Lay cables via the shortest route directly to the nearest edge of the backboard from mounted equipment or blocks. Secure all similarly routed and similar cables together and attach to D-rings vertically and/or horizontally, then route over a path that will offer minimum obstruction to future installations of equipment, backboards or other cables.

c. Cable terminating on patch panels located on racks:

- 1) Route cables in telecommunications rooms to patch panels on racks by routing across cable runway to top of rack and then down vertical cable management sections to patch panel.

d. Cable bundle combing:

- 1) Cable bundles shall be combed to present a neat and professional appearance. For performance reasons, combing shall occur from the cable end to a maximum of 35 feet back (or per the Manufacturer's recommendations, whichever is more stringent). For the portion of a cable bundle exceeding this requirement (if any), the exterior cables in the cable bundle shall be combed straight. Interior cables shall not be combed (i.e., they shall be left "mixed").

10. Cable bundles exiting floor or wall penetrations and running into furniture or casework shall be wrapped in spiral wrap or split-loom tubing for protection.
11. Cable Slack:
 - a. Except where otherwise noted, provide cable slack.
 - 1) For wall-mounted outlet locations:
 - a) Provide a minimum of 12 inches. Do not form a loop with the cable slack. Excess cable shall be pushed up the conduit.
 - b) Provide a minimum of 5 feet slack above the ceiling coiled per manufacturer's recommendations and supported off the ceiling grid or within the cable tray.
 - 2) At ceiling-mounted outlet locations (outlets for CCTV Cameras, Wireless Access Points, etc.), provide a minimum of 20 feet slack above the ceiling coiled per manufacturer's recommendations and supported off the ceiling grid or within the cable tray.
 - 3) In the telecommunications room, route cable around ladder rack to provide a slack loop of 10-feet minimum.

B. Copper Cable:

1. All pairs within a cable shall be terminated. Un-terminated cable pairs are not acceptable.
2. Maximum length of station distribution cable shall be 90 meters (including specified cable slack, see "Cable Slack" above). Do not exceed this length without prior approval from the Engineer.
3. Station cable which is exposed or not in conduit shall be routed to comply with ANSI/TIA-569-B requirements for avoiding potential EMI sources and as follows:
 - a. Provide clearances of 18 inches from light fixtures.
 - b. Provide clearances of 12 inches from conduit and cables for electrical power distribution.
 - c. Provide clearances of 4 feet from motors and transformers.
 - d. Pathways shall cross perpendicular to fluorescent lighting and electrical power cables or conduits.
4. Provide strain relief at the patch panels and at the outlets to ensure durable connections.

3.5 CABLE ASSEMBLIES (PATCH CORDS) AND CROSS-CONNECTS

- A. Provide cable assemblies to Owner.

3.6 TESTING

- A. Test devices shall be in calibration throughout the testing period. Tests performed on equipment without up to date calibration shall be rejected and shall be repeated at no additional cost to the Owner.

- B. Notify the Consultant and Owner seven (7) days in advance of each type of test to be conducted. The Owner and/or Consultant may, at their discretion, witness all testing. The Owner and Consultant shall be invited to attend and inspect the first instance of each type of test to be conducted. Tests conducted prior to first inspection shall be at the sole risk of the Contractor, and as such are subject to rejection. Such tests will be repeated at no additional cost to the Owner.
- C. Communications Cabling System
 - 1. Test the communications cabling system for compliance to the Governing Requirements and all applicable standards.
 - a. Visually inspect all labels at the station locations (faceplates/ports), patch panels/ports, and on each end of each cable to ensure that all cables and equipment are correctly identified.
 - b. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with ANSI/TIA-568-D.1.
 - c. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 2. Copper Cable:
 - a. For Horizontal Cabling: Test each copper station cable, all pairs. To the extent possible, tests shall be performed with building electrical systems fully powered on (i.e. Lights, HVAC, etc.).
 - b. Test each terminated cable using the end-to-end Permanent Link test (the entire link from the connector at the station to the connector or termination in the telecommunications closet) for the following test parameters:
 - 1) Insertion Loss.
 - 2) Length.
 - 3) Wiremap.
 - 4) Signal Delay and Delay Skew.
 - 5) Pair-to-Pair Near End Crosstalk.
 - 6) Power-Sum Near End Crosstalk.
 - 7) Pair-to-Pair Attenuation to Crosstalk Ratio Near-End.
 - 8) Power Sum Attenuation to Crosstalk Ratio Near-End.
 - 9) Pair-to-Pair Attenuation to Crosstalk Ratio Far-End
 - 10) Power Sum Attenuation to Crosstalk Ratio Far-End.
 - 11) Return Loss.
 - 12) Pair-to-Pair Alien Near-End Crosstalk Ratio (Category 6a only).
 - 13) Power Sum Alien Near-End Crosstalk Ratio (Category 6a only).
 - 14) Pair-to-Pair Alien Near-End Crosstalk Ratio Far-End (Category 6a only).
 - 15) Power Sum Alien Attenuation to Crosstalk Ratio Far-End (Category 6a only).

3. Cables and equipment that do not pass shall be identified to the Consultant. The source of the non-compliance shall be determined, corrected or replaced, and re-tested at no additional cost to the Owner. Provide new test results to the Consultant in the same manner as above.
 - a. If it is determined that a cable is at fault, remove the damaged cable and replace it with a new cable. Cable "repairs" are not acceptable.
 - b. The procedure for removing the cable shall be as follows:
 - 1) Prior to removal of the damaged cable and installation of the new cable:
 - a) Any cables which are in the same conduit, duct or innerduct as the damaged cable shall be tested, regardless of whether or not they are new cables installed as part of this project or existing cables installed prior to this project.
 - b) All test results shall be provided to the Consultant for approval.
 - 2) The damaged cable shall be removed and the new cable shall be pulled in.
 - 3) After the removal of the damaged cable and installation of the new cable:
 - a) The new cable shall be tested.
 - b) Any cables which are in the same conduit, duct or innerduct as the damaged cable shall be tested, regardless of whether or not they are new cables installed as part of this project or existing cables installed prior to this project.
 - c) All test results shall be provided to the Consultant for approval.
4. Save all test results in both tabular and graphical format.
5. Submit all test reports in both pdf and native tester format for review and approval.

END OF SECTION

SECTION 27 41 33

CATV DISTRIBUTION SYSTEM

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

A. General System Scope of Work:

1. In general, the contractor shall provide a complete system as described within the specifications and drawings.
2. The contractor shall provide, test, and warrant all work as required within the specifications and drawings, unless specifically noted otherwise.

1.2 SYSTEM DESCRIPTION

A. The following is a general description of the CATV distribution system. See the balance of the specifications and drawings for additional details.

1. Provide a complete and fully operational broadband CATV signal distribution system starting from the trunk output from the head-end equipment (head-end equipment and in-line trunk amplifier provided by the head-end provider).
2. The CATV distribution system shall support the transmission of cable, satellite, and off-air video over coaxial cable in the facility.
3. Distribute signal to all TV outlets to permit simple connection of EIA standard television receivers.
4. Coordinate directly with the system head-end provider (TVS) for the following:
 - a. Minimum and maximum signal strength, bandwidth and signal-to-noise ratio requirements at the TV outlets.
 - b. Head-end equipment rack location.
 - c. Trunk amplifier location.
5. Use signal strength and bandwidth requirements provided by head-end provider in conjunction with installed cable lengths and outlet quantities to determine multi-port tap and splitter requirements and quantities.
6. Provide additional in-line amplifiers with equalization on the trunk to meet strength and bandwidth requirements. Place amplifiers in IDF locations as required.
7. Meet all FCC requirements regarding low radiation of RF signal per FCC Part 15.
8. All active components shall be of solid state design. The system shall be designed to prevent direct pickup of signals from the building structure.
9. Design and install the system for 24 hours a day continuous operation.

B. CATV head-end equipment provided by other to consist of the following:

1. Head-end equipment rack
2. Antenna signal amplification/distribution within the equipment rack
3. Satellite channel tuners/demodulators
4. Modulators

5. Combiners
6. Amplifiers as required.

1.3 SUBMITTALS

- A. Provide shop drawings and product data per the Communications General Requirements. Additional requirements are as follows:
 1. Provide a backbone diagram identifying cable types and routing, all distribution components within the Server Room, as well as all TV outlets.
 2. Identify all calculated distribution component values on the backbone diagram.
 3. Identify calculated signal strength at each TV outlet, in dBmV.

1.4 RECORD DOCUMENTS

- A. Provide record documents per the Communications General Requirements. Additional requirements are as follows:
 1. Update the backbone diagram to identify installed cable types and routing, all distribution components within the Server Room, as well as all TV outlets.
 2. Identify installed distribution component values on the backbone diagram.
 3. Identify measured signal strength at each installed TV outlet, in dBmV.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Provide only new products, and include the manufacturer's original factory warranty, product documentation and the latest version of any software required for configuration and/or operation.
- B. Deliver products to the job site in the manufacturer's original packaging directly from the manufacturer or manufacturer's authorized distributor.
- C. Many specified products are prone to rapid technological evolution. The contractor shall be responsible for ensuring the installed products are the latest models and incorporate the latest performance improvements available within the same cost as the specified product. Secure approval from the Owner for any deviations from the specified product necessary to meet this requirement.

2.2 CABLE:

- A. Coaxial TV Outlet Cable: See Section 271500 – Communications Horizontal Cabling
- B. TV Jumper Cable: Provide 1-m long RG-6 jumpers from wall plate to TV.

2.3 PASSIVE DISTRIBUTION EQUIPMENT:

- A. TV Outlet Connectors:
 - 1. Description: F-connector module insert. Install and terminate using manufacturer approved devices and methods.
 - 2. Manufacturer:
 - a. Commscope
 - b. Approved Equivalent
- B. Directional Splitters and Multi-Port Taps:
 - 1. Description: 1 GHz.
 - 2. Acceptable Manufacturers:
 - a. Blonder Tongue
 - b. Toner
 - c. Approved Equivalent.

2.4 ACTIVE DISTRIBUTION EQUIPMENT

- A. Additional Trunk Amplifiers with equalization/tilt
 - 1. Description: 1 GHz
 - 2. Acceptable Manufacturers:
 - a. Blonder Tongue
 - b. Toner
 - c. Approved Equivalent.

2.5 HEAD-END EQUIPMENT

- A. Head-end equipment shall:
 - 1. Connect to a satellite and off-air HDTV antenna to provide HDTV television channels to the televisions throughout the facility.
 - 2. Be an all-in-one device to decrypt and transfer the signal to the distribution system.
 - 3. Provided with all necessary accessories for a full operational system.
 - 4. Support direct interaction with Service Provider.
 - 5. Have 16-slots for various equipment blades.
 - 6. Provide blanks for unused slots.
- B. Products:
 - 1. Chassis: Toner SMARTBOX CHASSIS-DN005655
 - 2. QAM Blade: Toner SMARTBOX- DN003390
 - 3. Satellite Receiver Blade: Toner SMARTBOX-DN006571
 - 4. ATSC Receiver Blade: Toner SMARTBOX-DN003393

PART 3 - EXECUTION

3.1 INSTALLATION

A. General

1. Execute work in accordance with State and local codes, regulations and ordinances.
2. Install work neatly, plumb and square and in a manner consistent with standard industry practice. Coordinate on-site installation with other trades, and carefully protect work from dust, paint and moisture as dictated by site conditions. The Contractor will be fully responsible for protection of his work during the construction phase up until final acceptance by the owner.
3. Install equipment according to manufacturer's recommendations. Provide any hardware, adaptors, brackets, or other accessories required by site conditions or as recommended by manufacturer for correct assembly and installation.
4. Provide any conduit sleeves through walls and above hard ceilings as required to route cable. Provide fireproofing in sleeves as required by local code.
5. Provide any additional cutting, drilling, fitting or patching required to complete the Work or to make its parts fit together properly. This includes but is not limited to:
 - a. Drywall mounting brackets (sheetrock rings) in walls for connector plates.
 - b. Cable sleeves through fire-rated walls.
6. The Contractor shall not damage or endanger a portion of the work or fully or partially completed construction of the Owner or separate contractors by cutting, patching or otherwise altering such construction, or by excavation except with written consent of the Owner and of any separate contractor.
7. Secure equipment and cabling firmly in place:
 - a. All supports, mounts, fasteners, attachments and attachment points shall support their loads with a safety factor of at least 5:1 for static loads and 8:1 for dynamic loads.
 - b. Do not impose the weight of equipment or cabling on supports provided for other trades or systems.
 - c. The Contractor is responsible for means and methods in the design, fabrication, installation and certification of any supports, mounts, fasteners and attachments.
8. Coordinate cover plates with field conditions. Size and install cover plates as necessary to hide joints between back boxes and surrounding wall.

B. Wiring Practice

1. General
 - a. All cabling shall be installed concealed in wall, conduit, surface raceway, or above lay-in ceilings. Install coax cable in conduit above non-accessible gypsum board ceiling.
 - b. Provide a minimum of 12' slack in all horizontal cable runs.
 - c. Outside jacket sheath of cable shall be undamaged and structurally sound.

- d. Provide proper temporary protection of cable after pulling is complete, but before final dressing and terminations are complete. Do not leave cable lying on floor. Bundle and tie wrap off floor until termination.
2. Cable Termination
 - a. Provide proper termination for each cable type throughout the system. Terminate cable following industry standards and manufacturers' instructions.
 - b. Provide end-of-line resistors for all unused tap ports.
 3. Labeling
 - a. Cabling and equipment shall be properly labeled.
 - b. Replace labels within five years if label does not remain adhered to surface because of adhesive failure or label print fades or becomes unreadable.

3.2 FINAL CATV SYSTEM TEST AND BALANCE

- A. The contractor shall test and balance the CATV system to obtain the levels, bandwidth requirements, and signal to noise ratio at each TV outlet as directed by the head-end provider.
- B. The contractor is responsible to provide all test equipment to perform the CATV system balance. The contractor shall adjust equipment as required to test and balance the system.
- C. Testing
 1. On completion of the system installation, perform the following tests:
 - a. Perform "burn-in" of system by leaving it operational for at least three days prior to official testing and certification.
 - b. Notify the owner/engineer a minimum of two weeks prior to testing so that he may, at his discretion, furnish representatives to witness the testing procedure and results.
 - c. Test cables, taps and splitters installed by performing a sweep system test from 5 to 750 MHz in 2 dBmv scale per division, and document tests by cable and floor.
 - d. With normal levels in system, field strength meter shall be tuned to picture carrier of each channel in turn and reading obtained on meter noted. Signal shall then be removed and the input to the trunk amplifier shall be terminated in 75 ohms. With field strength meter reading, note level of remaining noise in absence of signal and add a meter correction factor of 4 dB to reading. The difference between two readings is the system's signal to noise ratio, and shall not be less than 43 dB, or as directed by the head-end provider.
 - e. Connect standard TV receiver to each outlet and observe picture quality. No visible components of cross channel inter-modulation (windshield wiper effects), ghosting or beat interference shall appear in screen of receiver tuned to a normal signal.

- f. Should such a demonstration of performance show that system was not properly balanced and picture degradation is present or output gain is not as specified, make necessary changes or adjustments and a second performance demonstration will be arranged.
 - g. Should a second performance demonstration fail, correct system deficiencies under supervision of consultant hired by Engineer. The contractor shall bear any costs required to meet system specifications.
- 2. A hard copy of the test results shall be submitted for review to the owner's Project Superintendent in notebook format. Test report data shall reference cables by cable label.
- 3. Submit copies of the test results as described above prior to final acceptance and training. Include copies of the test results in the O&M manuals. Include the names of the individuals performing and witnessing the tests, and the manufacturer's name and model number of the test equipment used. Include a block diagram of the test setup for each test.

END OF SECTION

SECTION 27 51 16

PUBLIC ADDRESS SYSTEM

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required) PART 1 - GENERAL

1.1 GENERAL

- A. The requirements contained within this section are in addition to any requirements contained within other sections of the specifications. In the event of a conflict between the requirements of this section and other sections of the specifications, the more stringent requirement shall apply.

1.2 QUALIFICATIONS

- A. Authorized Distributor and Installer for product supplied. Authorized Distributor Letter from manufacturer will be required upon request of specifying authority.
- B. Applicable state licenses
- C. Certificate of successful completion of manufacturer's installation/training school for installing technicians of the equipment being proposed
- D. The Lead Engineer, Project Manager, and Lead Installing Technician assigned to this project each have at least five (5) years' experience in projects of this size and scope.
- E. The resources and manpower to complete this project without having to subcontract any work.

1.3 DESCRIPTION

- A. System Description:
 - 1. System to provide general (non-emergency) overhead paging for the facility.
 - 2. System platform is an analog paging system with an interface to the IP-based telephone system.
 - 3. Pages will be made from an IP phone to other IP phones and the paging system over the Owner's enterprise LAN via an Analog-to-IP Interface.
 - 4. Analog paging speakers shall be ceiling mounted, unless otherwise noted. See communications floor plans for speaker locations.
 - 5. IP phones and Analog paging speakers will be configured into zones through the Analog Paging system headend and software. Zones are as follows:
 - a. Each department is a separate paging zone.
 - b. Each contiguous public area not associated with a specific department is a separate zone.
 - 6. Configure all paging speakers within all areas to receive the paging stream.
 - 7. All system components shall be on generator power if available.
 - 8. All paging system equipment shall be installed in the Owner's server room, or other conditioned, secure space as directed by the Owner.

1.4 CODES, REGULATIONS AND STANDARDS

- A. The installation shall be in compliance with all applicable codes, ordinances and regulations in effect at the date of the contract including but not limited to the most recent editions of the following:
 - 1. Applicable local codes and ordinances
 - 2. NFPA101 Life Safety Code
 - 3. Uniform Building Code
 - 4. Governing fire department requirements
 - 5. Utility company requirements
 - 6. State Department of Labor requirements
 - 7. State Department of Health requirements
 - 8. National Fire Protection Association Standards
 - 9. State and Federal Safety and Health Laws
 - 10. NFPA 70 – National Electrical Code
 - 11. Americans with Disabilities Act / Accessibility Standards
 - 12. Federal Communications Commission
- B. If discrepancies occur between Contract Documents, local codes, national codes, utility requirements, etc., most stringent requirements shall apply.
- C. All equipment shall be equal to or exceed the minimum requirements of NEMA, IEEE, ASME, ANSI, TIA, and Underwriters' Laboratories.
- D. Should any change in plans or specifications be required to comply with governmental regulations, the Contractor shall notify the Owner at the time of submitting the construction schedule.
- E. Where reference is made to specifications or standards published by various organizations, the Work shall conform to the latest edition of such specifications or standards as amended and revised in effect at the date of Contract, unless a specific date is indicated.
- F. Where material is designated for certain applications, material shall conform to standards designated in the applicable building code governing the Work. Similarly, unless otherwise specified, installation methods and standards of workmanship shall also conform to specifications and standards required by such code. Where no particular material is specified for a certain use, Contractor shall select from choice offered in code upon approval by Owner/Project Engineer.
- G. Where such code, specification or standard does not provide all information necessary for complete installation of an item, comply with manufacturer's instructions for workmanship.
- H. Where specific articles, sections, divisions or headings for standards are not given, such standards shall apply as appropriate. Standards when included herein by abbreviations or otherwise shall form a part of Contract Documents. In the event of conflicts between cited Standards and/or the Contract Documents, the more stringent shall govern.
- I. Contractor's Duties and Responsibilities: Responsible when required by Contract Documents or written request from Project Engineer to deliver required proof that materials or workmanship, or both, meet or exceed requirements of standard.

- J. Standard's Abbreviations: Abbreviations used throughout the Contract Documents refer to associations, institutes, societies and other public bodies who publish standards that are readily available to the public. Whenever initials representing such a body are shown, followed by a number or a combination of numerals and letters, reference is to a particular standard to which Contractor shall conform. The number or combination of numerals and letters following abbreviation designates the particular standard to be followed.

1.5 WARRANTY

- A. In general, the Contractor shall warranty the system they are providing for a period of one (1) year after acceptance by the Owner. All materials, equipment, parts and labor are included within the warranty. System failures, faulting operations, system components, parts, etc. shall all be remedied and corrected to 100% satisfaction of the Owner.
- B. Where indicated elsewhere in the Contract Documents, specific systems may require additional warranty periods and terms. Warranties shall include materials, parts and labor.
- C. The following service requirements shall apply:
1. Contractor to return Owner service calls within 4 hours when made during regular business hours.
 2. The Contractor shall have personnel on site within 24 hours of the initial call to assess the problem.
 3. If the problem cannot be immediately and permanently resolved, the Contractor shall provide a temporary remedy or work-around satisfactory to the Owner within 48 hours after the initial call.
 4. The problem shall be permanently remedied and corrected to 100% satisfaction of the Owner within 10 business days after the initial call.
- D. All warranty services described above shall be provided at no additional cost to the Owner.
- E. Provide a Warranty certificate at the Project closeout.

1.6 POST-AWARD SUBMITTALS

- A. Submit product data and system shop drawings together at one time. Any product data or drawings submitted separately will be returned without review.
- B. Product Data shall be provided in PDF format as single document with bookmarks, and contain the following information:
1. Complete list of equipment proposed, including quantities, model numbers, manufacturer name and item description. Connectors and miscellaneous small hardware may be listed in total.
 2. Product cut sheets and other technical specification information provided by the manufacturer.
- C. Provide Shop Drawings in PDF format. Sheet size requirements:
1. Minimum: 18" x 24"
 2. Maximum: 36" x 48"

- D. Shop Drawings shall detail all work being provided by the Contractor, including but not limited to:
1. Cover sheet containing a drawing index, comprehensive symbol legend and installation notes.
 2. Details showing typical wiring configurations for each type of connector used in the project.
 3. Detailed signal flow and wiring diagrams including proposed wire numbers and location of devices and connections in the signal flow.
 4. Mounting details for each typical device installation.
 5. Detail for each typical sleeve and other fire-rated penetration.
 6. Plan views showing the location of all speakers, cable/conduit pathways, head-end and amplification equipment. Include locations of sleeves and other fire-rated penetrations. Identify speakers by channel and by zone.
 7. Partial Plan and elevation views showing the location of all installed equipment within equipment room(s). Include power outlets, conduit pathways and wall penetrations.
 8. Proposed initial settings and configurations for each device. This information can be provided through schematics, tables and software screen shots.
 9. Detailed schematic drawing of proposed power and signal grounding configurations.
 10. Provide dimensional information for all plans, sections, elevations and details. Indicate dimensions based on measurements taken on-site.

1.7 PROJECT COMPLETION SUBMITTAL

- A. Upon completion of the installation, the Contractor shall notify the Owner that the system is ready for final inspection. Prior to on-site final inspection the Contractor shall perform all testing necessary to ensure that the system meets the required performance criteria.
- B. Seven (7) days prior to the date scheduled for final inspection, the Contractor shall provide a complete set of the Completion Submittal. The Completion Submittal shall include the following:
1. Written statement that all systems are substantially complete and have been adjusted to meet all performance criteria described in these specifications.
 2. Product Data File, to be provided in PDF format as single document with bookmarks for each section:
 - a. Title page.
 - b. Table of Contents.
 - c. Warranty:
 - 1) Warranty statement for system as described in these specifications. Clearly explain conditions and limits of warranty and list items specifically excluded, such fuses, normal wear/tear or expendable items.
 - 2) List any components having manufacturers' warranties of more than one year and list length of their warranties.
 - 3) Provide Contractor's name, address, service department telephone number and procedure for obtaining service.

- d. Equipment List for each System:
 - 1) Manufacturer, model number(s) and quantity of each component.
 - 2) Brief description of each component.
 - e. Equipment Manuals:
 - 1) All manufacturers' operation manuals. Arrange alphabetically.
 - 2) List address and phone for any manufacturer not providing operation manual, or whose address and phone are not listed in the operation manual.
 - f. Operating Instructions:
 - 1) Brief description of the system including features and operational concepts.
 - 2) Numbered instructions in non-technical terms for basic set-up & operation
 - 3) Descriptions of advanced features, programming and control functions.
 - 4) Trouble-shooting procedures in a tabature-type problem/solution format.
 - g. Maintenance Instructions:
 - 1) Routine maintenance procedures.
 - 2) List replacement parts for major user-replaceable and expendable components of the systems. Indicate specific part numbers. Replacement parts include, but are not limited to, fuses, cable, speakers/speaker components, batteries, etc.
 - h. Report detailing final results of all tests and measurements described in these specifications.
 - i. Tables, schematics and software screen shots showing final settings and configurations of each device.
 - j. One half-size set of Project Record Drawings.
3. Full-size Project Record Drawings:
- a. Modify accepted shop drawings to record the actual installation.
 - b. Record serial numbers for all components, installed and portable. Indicate actual location of devices.
4. Software and Programming:
- a. Electronic copies of all files and programs used as an operational or support element of the system, including configuration programs and data files, control system source code and drivers.
 - b. List of all passwords used in software or hardware.
 - c. Written authorization by the Contractor for the Owner to use this information to maintain and support all systems installed as a part of this Project.
5. With one set of the Completion Submittals provide three (3) duplicates of each key required for operation of the systems. With all other sets provide one (1) duplicate of each key.

- C. After the final inspection visit(s) and all punch list items have been successfully addressed, revise the Completion Submittal as required to reflect any changes made to the systems.
- D. The cost to the Owner for additional inspections due to any variance between the state of completion as described by the submitted Project Completion Submittal and the actual state of completion observed during the final inspection may be withheld by the Owner from the Contractor's final payment to the extent of such expense.

1.8 SUBMITTAL REVIEWS

- A. Review of Contractor submittals (shop drawings, record drawings, etc.) are for general compliance with the contract documents. No responsibility is assumed for corrections, dimensions or details. Review does not relieve the Contractor from responsibility for compliance with the contract documents.
- B. An explanation of the Submittal Review Comments:
 - 1. "No Exceptions Taken." The submittal is complete and accurate per the contract documents. Do not re-submit.
 - 2. "Make Corrections Noted." The submittal is complete per the contract documents but includes minor variances from the contract documents. Make the changes noted but do not re-submit.
 - 3. "Amend And Resubmit." The submittal is substantially complete per the contract documents, but has significant variances from the contract documents. You must re-submit.
 - 4. "Rejected." indicates the submittal is incomplete per the contract documents. Rejected submittals are not reviewed by the Consultant. You must re-submit.
 - 5. "Submit Specified Item." The submittal is substantially complete and accurate per the contract documents, but is missing an item that the Consultant needs to review. Re-submit only the specified item.
- C. The cost to the Owner for re-review any submittal marked "Amend and resubmit" or "Rejected" may be withheld by the Owner from the Contractor's final payment to the extent of such expense.

1.9 PRODUCT SUBSTITUTIONS

- A. The Substitution procedure is required for any products which deviate from the specified manufacturer and model. This includes, but is not limited to, products submitted as "Comparable", as well as products submitted to meet the requirement for the Contractor to provide products incorporating the latest performance improvements as required by the System section.
- B. For substitutions offered as part of the bid submittal, submit all proposed substitutions as one package and at least (7) seven working days prior to the bid opening date.
- C. Products covered under these documents have been coordinated with other trades. Should Contractor propose and Owner accept variations or substitutions of the specified products at any time, Contractor shall have full responsibility for the coordinating and cost of required modifications to the work of other trades to accomplish the interface with the substituted product.

- D. The substitution procedure is as follows:
 - 1. The Contractor must submit information verifying performance, cost and availability criteria of each proposed substitution.
 - 2. There is no guarantee, expressed or implied, that any product substitution shall be accepted. The Owner may reject any proposed substitution without cause and without altering in any way the Contractor's contractual obligation to complete the Project.
- E. Substitutions must meet the following criteria for consideration:
 - 1. The proposed products shall offer superior performance without adding cost to the Contract.
 - 2. The proposed products shall offer equivalent performance and reduce cost to the Contract.
 - 3. The proposed product shall offer equivalent performance and is more commonly available in the region where the project is located.
 - 4. The specified products are no longer available.
 - 5. The proposed products avoid delays to the project that would be caused by the specified products.
 - 6. The specified products will not operate as intended due to unexpected field conditions.
- F. Once comparable products have been approved, any additional changes must be approved in writing by the Owner and will be treated as a substitution.
- G. Use the same products for the same use throughout the systems.
- H. Use only products from a single manufacturer for similar use throughout the systems unless otherwise specified.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Contractor is responsible for pricing all accessories and miscellaneous equipment required to form a complete system. Unless otherwise noted in this Part, equipment quantities shall be as indicated on the Drawings.
- B. Wherever the words "or comparable" are used in this section, it shall mean that the manufacturer or manufacturers listed compete in the same product categories as the primary listed manufacturer and so can reasonably be expected to manufacture a product that provides equivalent functionality, performance and specifications as the primary listed products. The Contractor must still secure approval for any comparable products using the substitution procedure outlined under this section
- C. All products within a given category for a particular system must be by the same manufacturer.
- D. All products described in this section by manufacturer and model number are to be considered the basis of design for defining the product specifications. The feature-set of said basis of design product shall be considered the minimum feature-set required, notwithstanding any summary description of features given within this section.

- E. Many products listed herein are particularly prone to rapid technological evolution. The Contractor shall be responsible for ensuring that the products installed are the latest models and incorporate the latest performance improvements available within the same cost as the specified product. For any deviations from the specified model number and manufacturer necessary to meet this requirement, the Contractor must still secure approval using the substitution procedure outlined under Product Substitutions under the Submittals section.

2.2 PRODUCTS

- A. Overhead Paging Enterprise Platform: Server and software required to provide configurable paging via the IP phone system between IP phones and to paging speakers.
1. Acceptable: Bogen PCM2000 Zone Paging system
 2. Prerequisites listed below are required for the proper installation and operation of the Overhead Paging Platform. Coordinate directly with the Owner to ensure these prerequisites are in place and properly configured:
 - a. Telephone Interface Module: Bogen Part No. PCMTIM.
 - b. Central Processing Module: Bogen Part No. PCMCPU.
 - c. 3-Zone Paging Module: Bogen Part No. PCMZPM.
 - d. Power Supply: Bogen Part No. PCMPS2
 - e. Amplifier: Bogen Part No. TPU100.
 - f. Ambient Noise Sensor and Sensor Microphone:
 - 1) Sensor: Bogen Part No. ANS501
 - 2) Sensor Microphone: Bogen Part No. ANS500m
 - g. IP-to-Analog Interface: Provided by Owner.
- B. Analog Paging Speakers:
1. Factory assembled loudspeaker, backbox and baffles and PCB amplifier.
 2. General:
 - a. Coordinate each loudspeaker type with its installation location per drawings.
 - b. Provide system licensing as needed to provide a fully functional system.
 3. Accessible Ceiling:
 - a. 2'x2' loudspeaker
 - b. Bogen Part No. CSD2X2VRU
 4. Inaccessible Ceiling:
 - a. Cut-in loudspeaker
 - b. Bogen Part No S86T725PG8WBRVR
 - c. Coordinate finish with architect and ceiling. Provide custom painted finish as needed for each location.
 5. See manufacturer's instructions for proper configuration.

6. Cabling:
 - a. Construction: 18 AWG stranded copper, 2 conductor, unshielded.
 - b. UP Listed CMP for placement in an air-handling plenum environment.
 - c. Part No.: Belden 6300UE, or approved equivalent.
- C. Fire and EMS System Equipment and Interface Devices:
 1. Manufacturer: Purvis Systems, Inc.
 2. Devices:
 - a. Station Control System Unit.
 - b. Audio Relay Expansion Module.
 - c. Dorm Remote Gateway, 32 Port.
 - d. Bunk Room Device.
 - e. Unit Presence Detector.
 3. Cabling:
 - a. Station Control System Unit: Category 6. See Specification Section 271500 for additional information.
 - b. Audio Relay Expansion Module: Category 6. See Specification Section 271500 for additional information.
 - c. Dorm Remote Gateway, 32 Port: Category 6. See Specification Section 271500 for additional information.
 - d. Bunk Room Device: 18/4 Shielded. Belden Part No. 6302FE.
 - e. Unit Presence Detector: 18/4 Shielded. Belden Part No. 6302FE.

PART 3 - EXECUTION

3.1 GENERAL

- A. The system shall be tested for proper operation to the satisfaction of Owner. The speaker output level of all areas shall meet the requirements of The Owner. Volume level changes shall be made to the Owner's satisfaction.

3.2 INSTALLATION

- A. General
 1. Execute work in accordance with State and local codes, regulations and ordinances.
 2. Install work neatly, plumb and square and in a manner consistent with standard industry practice. Coordinate on-site installation with the Owner, and carefully protect work from dust, paint and moisture as dictated by Owner requirements. The Contractor will be fully responsible for protection of his work during the construction phase up until final acceptance by the Owner.
 3. Install equipment according to manufacturer's recommendations. Provide any hardware, adaptors, brackets, rack mount kits or other accessories recommended by manufacturer for correct assembly and installation.

4. Secure equipment firmly in place, including speakers, shelves, cables, etc.
 - a. All supports, mounts, fasteners, attachments and attachment points shall support their loads with a safety factor of at least 5:1 for static loads.
 - b. Do not impose the weight of equipment or fixtures on supports provided for other systems.
 - c. Any suspended equipment or associated hardware must be certified by the manufacturer for overhead suspension.
 - d. The Contractor is responsible for means and methods in the design, fabrication, installation and certification of any supports, mounts, shelves, fasteners and attachments.
 - e. Mount and adjust speakers as needed to securely support speaker assembly.
 5. Mount all equipment in the Server Room in racks on walls, as indicated in the Server Room enlarged plans.
 6. Finishes for any exposed work shall be approved by the Architect or Owner.
- B. Server Room Location:
1. Furnish and install the specified headend paging system equipment as specified.
 2. Furnish and install the required number of amplifiers in each IDF to support the number of speakers on a given floor, with allowance for a minimum of 20% growth on given floor.
 3. Furnish and install the required number of termination blocks and strips to support the cabling being terminated
- C. Speaker Installation:
1. Furnish and install the specified paging system speakers at the locations shown on the drawings.
 2. Tap each indoor ceiling speaker at 1-Amp.
 3. Tap each indoor horn speaker in the Equipment Bay at 10-Amps.
 4. Tap each outdoor horn speaker at 10-Amps.
- D. Ambient Noise Sensor:
1. Provide the specified ambient noise sensor in the Server Room.
 2. Provide the specified ambient noise sensor microphone in the Apparatus Bay. Mount as close to the center of the bay as practical.
- E. Cabling:
1. Furnish and install the specified cabling between paging system head-end equipment in the Server Room location.
 2. Furnish and install the specified cabling between paging system equipment and speaker locations.
 3. Provide separate cable supports for paging system cable. Supports attached to the cable tray are permitted.
 4. Do not have more than 8 ceiling speakers on a given "daisy-chain" cable run.
 5. All speakers in a given room location will be connected together, and will then be "home-run" to the nearest IDF location.

3.3 TEST EQUIPMENT

- A. The Contractor shall furnish all test and computer equipment required for all testing and adjustments. The same equipment will be provided during any site visits by the Consultant.

3.4 PERFORMANCE REQUIREMENTS

- A. The speakers shall be adjusted to meet the following level and equalization criteria. All dB measurements are assumed to be dBSPL:
 - 1. With the gain structure set to unity with a -10dBU pink noise source connected at the source input, loudspeakers shall collectively generate 73dB (+/- 2dB) C-weighted throughout the entire direct coverage area.
 - 2. After adjustment to the above specifications, the speaker shall be tested for proper operation to the satisfaction of Owner. The speaker output levels and equalization for all areas shall meet the requirements of the Owner.

3.5 INSTRUCTION

- A. Contractor shall provide a qualified individual to provide a minimum 8 hours of instruction to the Owner regarding the design, features and proper operation of the Systems.

3.6 FINAL CLEANING

- A. At completion of work, remove all rubbish, tools, scaffolding, and surplus materials from the site. Site shall meet Owner's requirements for cleanliness.
- B. At completion of work, thoroughly vacuum floors and flat surfaces such as shelves, counters and window sills in the areas affected by the work.
- C. Coordinate removal or storage of packing materials with the Owner. Contractor shall remove all packing materials from the site unless otherwise directed.
- D. In the event the Contractor fails to perform Final Cleaning, Owner may do so and charge any associated costs back to the Contractor.

END OF SECTION

SECTION 27 43 13
SYNCHRONIZED CLOCK SYSTEMS

(Part of Work of Section 26 00 01 - ELECTRICAL, Trade Bid Required)

1.1 SUMMARY

- A. This Section specifies a master clock and program control system including the following components:
 - 1. Master clock and program control unit
 - 2. Secondary indicating clocks
 - 3. Program signal devices
 - 4. Clock circuit power boosters
 - 5. System wire and cable
- B. System Description
 - 1. System shall perform the following functions:
 - a. Supply power to remote indicating clocks
 - b. Maintain correct synchronized time and transmit time-correction signals over dedicated system wiring from a master clock to any type(s) of secondary clocks, including the following:
 - 1) Analog Synchronous Clocks: Correct for minute- and second-hand synchronization at least once each hour and for hour-hand synchronization at least once each day.
 - 2) Digital Clocks: Synchronize minute indication every hour and hour indication every 12 hours.
 - 2. Initiate and execute programs for scheduled automatic operation of remote devices. Include audible signal devices.
 - 3. Provide for manual control of programmed signal and equipment switching circuits.
 - 4. Communicate via Ethernet for time synchronization and to permit programming from remote location.
 - 5. Maintain system access security with a minimum of two levels of user-access control to restrict use of system controls to authorized personnel.
 - 6. Level of access applies to both local access and access from a remote computer. Access to user programming and control functions is accomplished by entering a minimum four-digit code.
 - 7. Regulate system timing function using power-line frequency, backed up for power outages by an internal battery-powered, crystal-controlled oscillator.
 - 8. System shall be capable of programming multiple independent event schedules into memory and running them simultaneously for different output circuits.
 - a. Quantity of Programmable Schedules: 99
 - b. Number of Weekly Events that can be programmed 9999
 - c. Simultaneous operation of independent schedules shall be limited only by the number of signal-device and equipment-switching output circuits.
 - 9. Daylight Saving Time Correction: Programmable for automatic adjustment.

10. Adjustments to Master Clock Output Signals: Duration of momentary signal shall be individually programmable for each signal and equipment-control output circuit from 1 to 9 seconds. Signals shall be programmable for either on or off switching to suit equipment-operation scheduling.

1.2 SUBMITTALS

- A. Product Data:
 1. For each type of product indicated.
 2. See Specification Section 270500, Common Work Results for Communications Systems for additional information.
- B. Operation and maintenance data.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices and Accessories: UL Listed

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by the following:
 1. American Time & Signal Company:
 - a. Analog Clock: Part No. PE56BAPD304.
 - b. Digital LED Clock: Part No. PGE461RSE.

2.2 MASTER CLOCK

- A. Description: Microprocessor-based, software-controlled unit having the following components and features:
 1. Programming and control capabilities.
 2. Informational Display: LED or backlit LCD type.
 - a. Normally shows current time, date, and day of week display.
 - b. Provides programming cues when system is being programmed.
 3. Output Circuits for Power and Correction of Secondary Indicating Clocks:
 - a. Wired Synchronous Clock Power Circuit and One Correction Circuit: For analog and digital clocks. Relay controlled.
 4. IEEE 802.3 10/100/1000BaseT communication port for time synchronization and remote programming.
 5. Circuits for audible signal devices: Relay controlled manually switchable, using controls on master clock. Rated 120-V ac, 10 A minimum. A minimum of six circuits.

6. Circuits for Programmable Switching of Remote Equipment and Circuits:
 - a. Relay controlled manually switchable, using controls on master clock.
 - b. Rated 120-V ac, 10 A minimum.
 - c. A minimum of six circuits.
7. Power Supplies: Capacity for internal loads and power and correction circuits of connected clocks.
8. Enclosure: UL Listed industrial control panel, surface mount with front panel latch. When cover is closed, display indication shall be visible through the cover.
9. 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 7 years.

2.3 PROGRAM SIGNAL DEVICES

- A. Loudspeakers for Audible Tones: Refer to Division 16 Section "Public Address System."

2.4 CLOCK CIRCUIT POWER BOOSTER

- A. Description: Transformer power supply, mounted in steel cabinet with hinged door, and having fuse-protected input and output circuits.

2.5 BACK BOXES FOR SECONDARY INDICATING CLOCKS AND PROGRAM DEVICES

- A. Description: Box and cover plate assembly shall be furnished by device manufacturer and be suitable for device to be mounted. Back boxes shall be equipped with knockouts and hanger straps or mounting adapters arranged for flush mounting device, unless otherwise indicated.

2.6 GUARDS

- A. Description: Formed-steel wire, shaped to fit around guarded device, with 1-inch (25-mm) maximum clearance.
 1. Mounting Provisions: Fixed tabs welded to guard and arranged for screw attachment to mounting surface.
 2. Finish for Indoor Devices: Clear epoxy lacquer over zinc plating or powder coat painted finish.

2.7 WIRE AND CABLE

- A. Conductors: Insulated copper, with minimum sizes as recommended by the connected device manufacturer. Voltage drop for signal, control, and clock correction circuits shall not exceed 10 percent under peak load conditions.
- B. 120-V ac and Class 1 Signal and Control Circuits: Stranded single conductors of size recommended by system manufacturer. Materials and installations requirements are specified in Division 16 Section "Conductors and Cables."
- C. Classes 2 and 3 Signal and Control Circuits: Single conductor or twisted-pair cable, unless manufacturer recommends shielded cable.
- D. Data Circuits: Category 6 minimum, unshielded, twisted-pair cable, unless manufacturer recommends shielded cable.

- E. Plenum Cable: UL-listed and labeled for use in air-handling spaces, plenums, and plenum ceilings.
- F. Conductor Color-Coding: Uniformly identified and coordinated with wiring diagrams.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Wiring: Install 60 Hz wiring according to national and local electrical codes. Furnish and install data cable in compliance with Section 271500, Communications Horizontal Cabling. Provide the number of cables and conductors recommended by the system manufacturer for functions indicated, and as follows:
 - 1. Conceal wiring except in unfinished spaces.
 - 2. Wiring Method: Install wiring in raceways.
 - 3. Wiring Method: Install wiring in raceways except for Classes 2 and 3 remote-controls and signaling circuits, as defined in NFPA 70, if installed in accessible ceiling spaces and hollow gypsum-board partitions, where unenclosed wiring method may be used. Install listed plenum cable for Classes 2 and 3 wiring in environmental air spaces, including plenum ceilings.
 - 4. Wiring Method: Install metal-clad cable except for Classes 2 and 3 remote-controls and signaling circuits, as defined in NFPA 70, if installed in accessible ceiling spaces and hollow gypsum-board partitions, where unenclosed wiring method may be used. Install listed plenum cable for Classes 2 and 3 wiring in environmental air spaces, including plenum ceilings.

3.2 ELECTRICAL CONNECTIONS

- A. Make splices, taps, and terminations on numbered terminal strips in junction, pull and outlet boxes, terminal cabinets, and equipment enclosures.
- B. Use plug connectors for connections to clocks.
- C. Ground clocks to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

3.3 IDENTIFICATION

- A. Comply with Specification Section 270553, Identification for Communications Systems.
- B. Color-code wire and apply wire and cable marking tape to designate wires and cables so they are uniformly identified and coordinated with wiring diagrams throughout the system.

3.4 FIELD QUALITY CONTROL

- A. Perform the following field adjustments, tests, and inspections and prepare test reports:
 - 1. Perform operational-system tests to verify compliance with the Specifications and make adjustments to bring system into compliance. Include operation of all modes of clock correction and all programming and manually programmed signal and relay operating functions.
 - 2. Verify all units and controls are properly labeled and interconnecting wires and terminals are identified.

- B. Remove and replace malfunctioning units and retest as specified above.

3.5 PROGRAMMING AND ADJUSTMENTS

- A. Program system according to Owner's requirements. Set system so signal devices operated 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 sound-output level of adjustable signal devices to suit Owner's requirements.

END OF SECTION

SECTION 280500

COMMON WORK RESULTS FOR SECURITY SYSTEMS (Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. General provisions of the Contract, including Contract Requirements and Division 1 Specification Sections, and any General Contractor applicable General Conditions apply to this Section.

1.2 PROJECT SUMMARY

- A. General Scope of Work:
 - 1. Provide security systems components, cabling, and infrastructures as directed in these specifications and the drawings.
 - 2. Provide a new access control, intrusion detection and video surveillance system as directed in these specifications
- B. Active LAN switch equipment required for the IP cameras and other network connectivity required by the security systems will be provided by the owner.
- C. Provide, install, test, and warrant all work as required within these documents, unless specifically noted otherwise.
- D. Follow the general project construction schedule and phasing plan provided by the General Contractor and shall meet all construction and Owner move-in requirements.
- E. Follow the General Contractor's schedule and attend progress meetings as needed. A General Schedule is to be submitted with bid.
 - 1. Within seven (7) days of the tentative award of contract, prepare and submit a detailed schedule using "Microsoft Project" software or equivalent. It shall be prepared in the Gantt chart format. The Contractor Project Schedule (CPS) shall indicate detailed activities for the projected life of the project. The CPS shall consist of detailed activities and their restraining relationships, including such milestones, constraints, and interfaces with separate Owner-awarded contracts as the Owner may elect to include. The CPS shall include indications of the activity points at which each key item of material or equipment must be available on-site in order that the scheduled work can proceed as planned.
 - 2. Preparation of Detail Schedule: In preparing the Contractor Project Schedule (CPS), meet with the Owner/Owners Representative and the General Contractor to develop detailed activity information, including staffing for the project. Provide anticipated submittal date, for fabrication and delivery duration's for key construction materials, systems and equipment. The CPS shall contain an adjustable time-scaled schedule using a critical path method (CPM) precedence diagramming system.

- F. Participate in Project Meetings held in facilities provided by the Owner/Owners' Representative. These meetings shall be held weekly, at a time agreed by the Owner/Owners' Representative to establish the current state of completion, review coordination issues, and revise the schedule as necessary.
- G. The construction schedule, as accepted by the Owner/Owners' Representative shall be an integral part of the Contract with the Owner/Owners' Representative, and shall establish interim contract completion dates for the various activities. The schedule must remain adjustable and flexible throughout the length of the project.
- H. Purchase critical materials at the time the Contract is awarded so that delays and substitutions will not be necessary when the time comes to incorporate these materials into the Work.
- I. Regulatory Requirements and Fees: Deliver copies of all permits, licenses, warranties and certificates to the Owner and General Contractor prior to final payment.
- J. Contract Document Format and Language
 - 1. The Drawings: The Drawings are graphic and pictorial portions of the Contract Documents, wherever located and whenever issued, showing the design, location and dimensions of the Work, generally including plans, elevations, sections, details, schedules and diagrams.
 - 2. The Specifications: The Specifications are that portion of the Contract Documents consisting of the written requirements for materials, equipment, construction systems, standards and workmanship for the Work, and performance of related services.
 - 3. In the event of conflict between the drawing and specification, the greater quantity/quality is to be used.
 - 4. The Project Manual: The Project Manual is the volume usually assembled for the Work which may include the bidding requirements, sample forms, Conditions of the Contract and Specifications.
 - 5. Unless otherwise stated in the Contract Documents, words which have well-known technical or construction industry meanings are used in the Contract Documents in accordance with such recognized meanings.
 - 6. The Specifications are organized in sections of work based upon the Construction Specification Institute's (CSI) format.
 - a. The organization of the Specifications in sections is not intended to imply trade responsibilities.
 - b. Section titles are not intended to limit the meaning or content of a section, or to be completely descriptive of requirements specified within a section.
 - 7. The imperative language is used generally in the Specifications. These statements in this Section are directed to the "Security Systems contractor". The term "Security Contractor" may also be used.
 - 8. Colons:
 - a. Colons are used in the Specifications to list requirements generally for products.
 - b. The words "shall be" shall be supplied by inference where a colon (:) is used for such purpose.

9. Miscellaneous Definitions

- a. The term "product" shall mean and includes materials, systems, and equipment.
- b. Whenever the terms "accepted", "directed", "selected", "required", "submitted", or similar words and phrases are used in the Contract Documents, it shall be assumed that the word "Project Engineer" follows the verb as the object of the clause, such as "...accepted by the Project Engineer", and "...submitted to the Project Engineer", the Project Engineer being a designated Owners on site representative.
- c. The term "furnish" shall mean to furnish products and supervision.
- d. The term "install" shall mean to supply labor and supervision to erect, install and correct.
- e. The term "provide" shall mean collectively furnish and install as defined above.
- f. The term "exposed" shall mean exposed-to-view when the project is substantially complete.
- g. The term "concealed" shall mean not exposed-to-view when the project is substantially complete.
- h. The terms "acceptable", "proper", and other qualifying words shall imply evaluation and judgment by the Owner's Project Engineer (OPM).
- i. Singular words in the Contract Documents shall be considered plural where required by the subject under discussion.
- j. The term "similar" shall mean and be interpreted in its general sense and not as meaning identical, and all details shall be suited to the location and to the connection with other parts of the work.
- k. The term "as specified" shall mean collectively all terms, requirements, stipulations, etc., as described for the respective equipment, materials or methods in the Contract Documents.
- l. The term "as indicated" shall mean as indicated on the Drawings.
- m. The term "Engineer" or "Project Engineer" shall mean the Owner-designated representative having authority to issue instructions and allow approvals, and act as the Owner's agent.

1.3 PROJECT MANAGEMENT AND QUALITY ASSURANCE

A. Description

1. Contractor shall be solely responsible for quality control and shall maintain quality control over supervision, subcontractors, suppliers, manufacturers, products, services, workmanship, and site conditions, to produce Work in accordance with Contract Documents.
2. Work shall be free from faults and defects in workmanship. Materials and equipment incorporated into the work shall be new, unless noted otherwise.
3. Required testing and inspection are intended to assist in determination of probable compliance of the work with the Contract Documents, but will not relieve Contractor of responsibility for this compliance. Specified testing and inspection are not intended to limit Contractor's quality control program.

B. Workmanship

1. Standards: Comply with industry standards, except when tolerances that are more restrictive or specified requirements indicate more rigid standards or workmanship that is more precise.

2. Anchorage: Secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, and racking.

C. Services of Manufacturers and Suppliers

1. Manufacturer's Instructions: Require compliance with instructions in full detail, including each step in sequence. Should instruction conflict with Contract Documents, request clarification from Manufacturer before proceeding.
2. Manufacturer's Certificates: When required in individual Specifications section, submit manufacturer's certificate, in duplicate, certifying that products meet or exceed specified requirements, executed by responsible officer.
3. Manufacturer's Field Services: When required in individual Specifications section, have manufacturer or supplier provide qualified representative to observe field conditions, conditions of surfaces and installation, quality of workmanship, start-up of equipment, test and adjust equipment as applicable and to make written report of observations and recommendations.

D. Coordination of Work

1. Carefully check space requirements and the physical confines of the area of work to insure that all material can be installed in the spaces allotted thereto, including conduits and cable supports.
2. Transmit to other trades in a timely manner all information required for work to be provided under their respective Sections in ample time for installation.
3. Wherever work interconnects with or contacts the work of other trades, coordinate with other trades to insure that all trades have the information necessary so that they may properly install all the necessary connections and equipment. Identify all items of work that require access so that the floor tile trade will know where to install tile cutouts.
4. Due to the type of installation, a fixed sequence of operation is required to properly install the complete systems. Coordinate project and schedule work with the General Contractor in accordance with the construction sequence. Provide progress status of the installation to the General Contractor to allow them to update their project schedules.
5. When directed by the General Contractor, the Contractor shall, without additional fee, make reasonable modifications in the layout as needed to prevent conflict with work of other trades or for proper compliance with the design intent.

E. Supervision and Construction Procedures

1. Supervise and direct the Work using proper skill and attention. The Contractor shall be solely responsible for and have control over construction means, methods, techniques, sequences and procedures and for coordinating all portions of the Work under the Contract, unless Contract Documents give other specific instructions concerning these matters.
2. The Contractor is responsible to the Owner for acts and omissions of their employees, subcontractors and their agents and employees, and other persons performing portions of the Work under a contract with the Contractor.
3. The Contractor is not relieved of obligations to perform the Work in accordance with the Contract Documents either by activities or duties of the Project Engineer or his representatives in the administration of the Contract, or by tests, inspections or approvals required or performed by persons other than the Contractor.

4. The Contractor is responsible for inspection of portions of Work already performed under this Contract to determine that such portions are in proper condition to receive subsequent Work.
 5. Take field measurements where applicable. Verify field conditions, and carefully compare such field measurements and conditions and other information known to the Contractor with the Contract Documents before commencing activities. Errors, inconsistencies, or omissions discovered shall be reported to the Engineer at once.
 6. If the contractor performs work contrary to laws, statutes, ordinances, building codes, and rules and regulations, the contractor shall assume full responsibility for such Work and shall bear the attributable costs.
 7. Examine substrates and conditions under which product are to be installed and verify that the Work may commence. Do not proceed with the Work until unsatisfactory conditions have been fully resolved.
 8. Manufacturer's Instructions: Comply with manufacturer's instructions and recommendations, except where more stringent requirements are shown and except where project conditions require extra precautions or provisions to ensure satisfactory performance of Work.
 9. Provide a lead foreperson or supervisor on-site who can make decisions and represent the Contractor.
- F. Source Quality Control: Provide each type of material, product or system from a single source or manufacturer for the entire project and provide accessories, fittings, anchorages or similar items as provided or recommended by primary materials manufacturer. Do not change brand, type, or style.
- G. Replacement and Correction
1. Promptly replace or correct all work found not to be in compliance with the requirements of the Contract Documents and the requirements of any public authority having jurisdiction so as not to delay the Work or the work of other contractors regardless of how such failure to comply may be revealed. Replacement and correction shall be expedited as required to maintain interim contract completion dates and the full completion date.
 2. The Engineer may require additional testing and inspection of work previously found not to be in compliance until such work has been properly replaced or corrected. Such additional testing and inspection shall be at Contractor's expense.
 3. The Contractor shall promptly remedy damage wrongfully caused by the Contractor to completed or partially completed construction or to property of the Owner or separate contractors.
- H. Safety of Persons and Property
1. Institute a Safety Program and shall take reasonable precautions for safety of, and shall provide reasonable protection to prevent damage, injury or loss to:
 - a. Employees on the worksite and other persons who may be affected thereby.
 - b. The Work and materials and equipment to be incorporated therein, whether in storage on or off the site, under care, custody or control of the Contractor or the Contractor's Subcontractors.
 - c. Other property at the site or adjacent thereto, such as trees, shrubs, lawns, walks, pavements, roadways, structures and utilities not designated for removal, relocation or replacement in the course of construction.

2. Give notices and comply with applicable laws, ordinances, rules, regulations and lawful orders of public authorities bearing on safety of persons or property or their protection from damage, injury or loss.
- I. Transportation, Handling, Storage and Protection
 1. Handle and store materials and equipment in accordance with manufacturer and supplier's recommendations and store packaged materials and equipment in original, undamaged condition with manufacturer's labels and seals intact.
 2. Arrange for storage in protected and secured location. Provide for access for inspection. Maintain stored materials and equipment in a neat and orderly condition at all times.
 3. All materials stored are the responsibility of the Contractor until final acceptance by the Owner.
 - J. Daily Cleanup and Project Cleanliness
 1. Coordinate and check all areas where work is performed to ensure that a complete and thorough cleanup is performed to allow for the regular operation of the activities the area is designed for on a daily/shift basis. This is especially critical in areas where the work is completed after hours and on weekends to prevent disruption of daily activities.
 2. Cleanup shall include all equipment, parts, waste, liquid, and dust as a result of work being performed.
 3. Clean-up shall be continuous when working during normal business hours, or when working in occupied spaces.

1.4 PROJECT MEETINGS

- A. Participation
 1. Contractor's Duties: Participate in weekly project meetings at the job site with the Owner and Owner's Engineer or Representative.
 2. Participate in General Contractor's weekly meetings to facilitate timely coordination, schedule alignment, inspection reviews, information sharing, etc.
 3. Participate in a weekly cabling system project meeting if deemed necessary by the Owner or General Contractor.
 4. Authorized Representatives: Representatives of separate contractors, subcontractors and suppliers attending meetings shall be qualified and authorized to act on behalf of entity each represents.
- B. Pre-Construction Meeting
 1. Scheduling: Schedule Pre-Construction Meeting within five (5) days of Contract Award.
 2. Attendance:
 - a. Owner/Owners' Representative
 - b. General Contractor
 - c. Engineer
 - d. Contractors' Superintendents and Foremen

C. Typical Security System Project Meeting Requirements

1. Attendance
 - a. General Contractor Representative
 - b. Engineer or Representative.
 - c. Program Manager and Owner.
 - d. Contractors' Project Manager and Superintendents.
2. Minimum Agenda
 - a. Previous Meeting Minutes.
 - b. The Contractor's Project schedule.
 - c. Updated construction schedules.
 - d. Claims for modifications to contracted scope of work.
 - e. Critical work sequencing.
 - f. Major equipment deliveries, priorities, and stored materials.
 - g. Project Coordination:
 - 1) Critical near term.
 - 2) Designation of responsible personnel.
3. Procedures and processing of:
 - a. Field decisions.
 - b. Proposal requests.
 - c. Submittals and Submittals Schedule.
 - d. Change Orders.
 - e. Applications for Payment.
 - f. Contract close-out procedures.
4. Quality Control:
 - a. Updated punch list.
 - b. Documentation of correction made during previous week.
5. Adequacy of distribution of Contract Documents.
6. Procedures for maintaining Record Documents.
7. Use of premises:
 - a. Office, work and storage areas.
 - b. Owner's requirements.
8. Construction facilities, controls and construction aids.
9. Temporary utilities.
10. Safety and first-aid procedures.
11. Security procedures.
12. Parking/Transportation procedures.
13. Housekeeping procedures.
14. Special Contract requirements, including but not limited to:
 - a. Allowable locations of storage and temporary construction facilities.
 - b. Allowable delivery times.
 - c. Allowable use of public roads.
 - d. Workers' conduct.
15. Review of work progress since previous meeting.
16. Review field observations, problems, and conflicts.

1.5 TEMPORARY FACILITIES AND CONTROLS

- A. Conservation: Install and operate temporary facilities and perform construction activities in manner which reasonably will be conservative and avoid waste of energy and materials including water and electric power.
- B. Conditions of Use: Install, operate, maintain and protect temporary facilities in a manner and at locations which will be safe, non-hazardous, sanitary and protective of persons and property, and free of deleterious effects.
- C. Temporary Controls
 - 1. General: Determine methods and procedures to be used and assume responsibility for proper protection and safety of personnel.
 - 2. Temporary Barriers and Enclosures: Provide and maintain suitable temporary barriers, partitions and signs necessary to protect general public and workers for the Security Systems work area.
 - 3. Keep the premises free from the accumulation of debris, rubbish, and other waste material. Remove all such material from the project site at least once every week. In addition, the building Security Systems work area (i.e. electrical closets, etc.) shall be kept free from the accumulation of dust and dirt and shall be broom cleaned at least once every week. Should Contractor fail to provide cleaning as prescribed, Engineer may arrange for the cleaning and the costs thereof shall be deducted from the Contract Sum. Should a dispute arise between Contractor and other contractors as to the responsibility for cleaning, the Engineer or the General Contractor may arrange for the cleaning and the portion of the cost thereof, as the Engineer or General Contractor determines to be just, shall be deducted from the Contract Sum.
 - 4. Take all precautions and provide all protection necessary to ensure that building floors or ceiling tiles will not be marked, spotted, stained or damaged in any way.
- D. Construction Equipment: Assume responsibility for construction strength, placing and operation of construction equipment used for work to ensure that any load supported thereon can be carried.
- E. Temporary Fire Protection
 - 1. When burning, melting, welding, or using any other flammable device, a maintained ABC type fire extinguisher shall be located at location of such activity.
 - 2. No burning or burying of debris on site is allowed.
 - 3. Provide temporary fire proofing of ALL cores sleeves through floor slabs or fire rated partitions used in the installation of communications cabling. Use two-hour rated "pillows" to temporarily seal each core opening until permanent fire proofing sealant has been properly installed.
 - 4. Comply with the General Contractor's published site rules.
- F. Security: The Contractor is responsible for the good conduct of all personnel on site and for the security of equipment, tools, and project materials until the time of final acceptance by the General Contractor and Owner.

- G. Temporary Support Facilities: The types of temporary support facilities required include, but are not limited to: field offices, first aid facilities, bulletin board, telephones and temporary toilet facility. Locate temporary support facilities for convenience of users, and for minimum interference with construction activities.

1.6 PROJECT RECORD DOCUMENTS

A. Summary Description

1. General: Throughout progress of the Work, maintain an accurate record of changes in Contract Documents. Upon completion of Work, transfer recorded changes to a set of Record Documents using AutoCAD. An AutoCAD file of the drawings will be provided for contractor use.
2. Definitions: Record Documents are defined to include those documents or copies relating directly to performance of the Work, which Contractor is required to prepare or maintain for Owner's records recording Work as actually performed. In particular, Record Documents show changes in Work relation to way in which work was shown and specified by the original Contract Documents; and show additional information of value to Owner's records, but not indicated by original Contract Documents. The record AutoCAD drawing files shall indicate all device locations, cable labeling, riser cabling routes, equipment room lay-outs, backboard elevations, detail drawings and head-end connections. Record Documents include newly-prepared Drawings (if any are specified), mark-up copies of Contract Drawings and Shop Drawings, marked-up copies of Specifications, Addenda and Change Orders, marked-up Product Data Submittals, record Samples, Product List, field records for variable and concealed conditions and miscellaneous record information on Work which is otherwise recorded only schematically or not at all. Certain individual Work sections of these specifications indicate specific Record Document requirements, which extend requirements of this Section.

B. Quality Assurance

1. General: Delegate responsibility for maintenance of Record Documents to one person on Contractor's staff.
2. Accuracy of Records: Coordinate changes within the Record Documents, making adequate and proper entries on each page of Specifications and each sheet of Drawings and other Documents where such entry is required to show change. Accuracy of records shall be such that future searches for items shown in the Contract Documents may reasonably rely on information obtained from the Record Documents.

C. Description of Requirements

1. Record Drawings:
 - a. Mark-up Procedure: During progress of Work, maintain a printed set of Contract Drawings and Shop Drawings in clean, undamaged condition with mark-up of actual installations which vary from Work as originally shown. Mark whatever drawing is most capable of showing actual physical condition, fully and accurately. Where Shop Drawings are marked up, mark cross-reference on Contract Drawings at corresponding location. Mark with erasable colored pencil, using separate colors where feasible to distinguish between changes for different categories of Work at same general location.

- b. Mark-up important additional information which was either shown schematically or omitted from original Drawings. Give particular attention to information on Work concealed, which would be difficult to identify or measure and record at a later date. Note alternative numbers, Change Order numbers and similar identification. Each person preparing markup shall initial and date markup and indicate name of firm.
 - c. In preparation for Certification of Substantial Completion, review completed mark-up of Record Drawings with the Project Engineer. Prepare a full set of AutoCAD generated corrected drawings for Contract Drawings and Shop Drawings using AutoCAD software. Incorporate changes and additional information previously marked-up on print sets, by erasing and redrawing where applicable, and by adding details and notations where applicable; refer instances of uncertainty to the Project Engineer for determination. Identify and date each updated Drawing.
 - d. Prior to forwarding to the Engineer, submit corrected drawings to the Engineer for review and acceptance. The Engineer will review each drawing for general scope of changes and information recorded thereon, and of general quality of draftsmanship thereon (erasures and drafting). Drawings will be returned to Contractor for organizing into a set and for final submittal.
2. Record Specifications: During progress of the Work, maintain one copy of Specifications, including Addenda, Change Orders and similar modifications issued in print form during construction, and mark-up variations (of substance) in actual Work in comparison with text of Specifications and Modifications as issued. Give particular attention to substitutions, selection of options, and similar information on Work where it is concealed or cannot otherwise be readily discerned at a later date by direct observation. Note related Record Drawing information and Product Data, where applicable. Mark up exact locations of equipment, racks, cable rack trays, cabinets, etc. on the furnished drawings in the specifications. Upon completion provide changes in an AutoCAD format and, submit to the Engineer.
3. Record Product Data:
 - a. Mark-up Procedure: During progress of Work, maintain one copy of each Product Data submittal, and mark-up significant variations in actual Work in comparison with submitted information. Include both variations in product as delivered to project site, and variations from manufacturer's instructions and recommendations for installation. Give particular attention to concealed products and portions of the Work which cannot otherwise be readily discerned at a later date by direct observation. Note related Change Orders and mark-up of Record Drawings and Specifications. Upon completion of mark-up, provide changes using AutoCAD and submit completed AutoCAD set of documents to the Engineer.
 - b. Product List: Prior to final completion, submit final up-to-date Products List.
4. Miscellaneous Record Submittals: Refer to other sections of Specifications for requirements of record keeping and Submittals in connection with actual performance of Work. Prior to dates of Substantial Completion, complete records and place in good order, identified and bound or filed, ready for continued use and reference. Submit to the Engineer.

1.7 PROJECT CLOSEOUT

A. Cleaning:

1. Maintain a clean working environment throughout the entire job.
2. Prior to final inspection and acceptance of the Work, remove all debris, rubbish, waste material, tools, construction equipment, machinery and surplus materials from the Project site and thoroughly clean the Security Systems work area.
3. Thoroughly clean all system materials and components. All surfaces shall be free of dust and dirt.

B. Substantial Completion

1. Contractor:

- a. Submit written notice to Engineer that Project is substantially complete.
- b. Submit list of items (punch list) to be completed or corrected. Failure to include any items on such list does not alter responsibility of Contractor to complete all Work in accordance with Contract Documents.

2. Inspection:

- a. Engineer will make an inspection after receipt of notice.
- b. Should Engineer consider that Work is Substantially Complete:
 - 1) Owner will accept work as noted "Acceptably Completed".
 - 2) Contractor shall complete Work listed for completion or correction, within designated time.
- c. Should Engineer consider that Work is not Substantially Complete:
 - 1) The Engineer shall notify Contractor in writing, stating reasons.
 - 2) Contractor will complete Work, and send second written notice stating that Project is Substantially Complete.
 - 3) Engineer will re-inspect Work.

C. Final Inspection

1. Contractor shall submit written notice that:

- a. Contract Documents have been reviewed.
- b. Project has been inspected for compliance with Contract.
- c. Work has been completed in accordance with the Contract.
- d. Project is completed, ready for final inspection as described in the General Conditions.

2. Inspection:

- a. Engineer will make final inspection after receipt of notice.
- b. Should Engineer consider that Work is finally complete in accordance with Contract Documents, the Engineer shall request Contractor to make Project Closeout submittals.
- c. Should Engineer consider that Work is not finally complete:
 - 1) The Engineer shall notify Contractor, in writing, stating reasons.
 - 2) Contractor shall take immediate steps to remedy the stated deficiencies, and send second written notice certifying that Work is complete.
 - 3) Engineer will re-inspect Work.

- D. Closeout Submittals: Submittals: On or before Date of Substantial Completion, submit the following:
 - 1. Operation and Maintenance Manuals.
 - 2. Test Report:
 - a. Spreadsheet of all access control components tested for proper functionality.
 - b. Spreadsheet of all cameras tested for proper viewing angle, proper focus and correct recording specifications.
 - c. Spreadsheet of all emergency call stations tested for proper functionality.
 - 3. Spare Parts and Maintenance Materials.
 - 4. Return any existing equipment which had been removed during the Project.
 - 5. Deliver evidence of compliance with requirements of governing authorities: Low voltage certificates of Inspection.
 - 6. Service contracts.
 - 7. Project record documents in electronic format.
 - 8. As-built documentation in electronic format.
- E. Instructions
 - 1. Section Cross-Reference: Refer to Division 1 Sections.
 - 2. Operational Instructions: Instruct Owner's personnel in operation of any system and equipment.
- F. Final Application for Payment: Contractor shall submit final application in accord with requirements of General Conditions of Contract.
- G. Return of Contract Documents: Drawings, details, sketches and specifications, are property of Owner, and are issued to Contractor as instruments of service only. If required, Contractor shall return same to Owner.
- H. Post-Construction Inspection
 - 1. Prior to expiration of one year from Date of Substantial Completion, Engineer will make visual inspection of Project to determine whether correction of Work is required, in accordance with provisions of Conditions of Contract.
 - 2. Engineer will notify Contractor, in writing, of observed deficiencies.

1.8 SUBMITTALS

- A. General
 - 1. Contractor:
 - a. The Contractor shall review, accept and submit to the Engineer, shop drawings, product data, samples and similar submittals for all products and material; and as required by the Contract Documents. Submittals made by the Contractor which are not required by the Contract Documents may be returned without action.
 - b. Preparation: Prepare shop drawings, product data and samples and other submittals for submission.
 - 1) Determine and verify:
 - a) Field measurements.
 - b) Field construction criteria.

- c) Catalog numbers and similar data.
 - d) Conformance with specifications.
- 2) Coordinate each submittal with requirements of Work and of Contract Documents.
 - a) Representation: By acceptance and submittal of shop drawings, samples or product data, the Contractor represents determination and verification of field measurements, field construction criteria, materials, dimensions, catalog numbers, and similar data, and that Contractor has checked and coordinated each item with other applicable accepted shop drawings and contract requirements.
 - b) Conformance: Project work, materials, fabrication, and installation shall conform to accepted shop drawings, applicable samples, and product data.
- c. The Engineer and the General Contractor will review and accept or take other appropriate action upon the Contractor's submittals such as shop drawings, product data and samples, but only for the limited purpose of checking for conformance with information given and the design concept expressed in the Contract Documents. Review of such submittals is not conducted for the purpose of determining the accuracy and completeness of other details such as dimensions and quantities, or for substantiating instructions for installation or performance of equipment or systems, all of which remain the responsibility of the Contractor. The review of the Contractor's submittals shall not relieve the Contractor of any specified obligations. The review shall not constitute acceptance of safety precautions or, of any construction means, methods, techniques, sequences or procedures. The acceptance of a specific item shall not indicate acceptance of an assembly of which the item is a component. The Contractor shall not be relieved of responsibility for deviations from requirements of the Contract Documents by the Project Engineer's acceptance of shop drawings, product data, and samples of similar submittals. The Contractor shall not be relieved of responsibility for errors or omissions in shop drawings, product data, samples or similar submittals by the Engineer thereof.
- d. When professional certification of performance criteria of materials, systems or equipment is required by the Contract Documents, the Engineer shall be entitled to rely upon the accuracy and completeness of such calculations and certifications.

B. General Submittal Requirements

1. General:

- a. Shop drawings, product data, samples and similar submittals are not Contract Documents. The purpose of their submittal is to demonstrate for those portions of the Work for which submittals are required the way the Contractor proposes to conform to the information given and the design concept expressed in the Contract Documents.
- b. The Contractor shall perform no portion of the Work requiring submittal and review of shop drawings, product data, samples or similar submittals until the respective submittal has been accepted by the reviewers.

2. All submittals which require product data, shop drawings and samples shall be prepared together and submitted to the Engineer at one time in PDF electronic format.
3. Transactions: Transactions shall be through the Project Engineer. Inform each manufacturer, vendor, distributor, and material supplier of requirements concerning submission of required submittals.
4. Submission Date: The submittal and associated samples shall be submitted to the Project Engineer and received within five (5) days of contract award. Submittals will be reviewed and returned to the Contractor within three (3) days. Submittals shall be emailed or transferred via an online file sharing service.

C. Identification

1. General: Submittals shall have the following identification data, as applicable.
 - a. The date of submission.
 - b. The Project title and location.
 - c. Contract identification.
 - d. The names of:
 - 1) Contractor
 - 2) Installer
 - 3) Supplier
 - 4) Manufacturer
 - e. Identification of product (brand name, model number), use, and location with specification section number.
 - f. Field dimensions, clearly identified as such.
 - g. Relation to adjacent or critical features of Work or materials.
 - h. Applicable standards.
 - i. Identification of deviations from Contract Documents.
 - j. Identification of revisions on resubmittals.
 - k. An 8" x 3" blank space for Engineer's stamp and comments.
2. Shop Drawings: Title, drawing number, revision number, and date of drawing and revision.
3. Project Data: Each separate catalog, brochure, or single page submitted shall have an attached number. Catalogs or brochures submitted containing multiple items need the identification only on the cover, however, specific products for the project within such multiple item catalogs must be clearly identified including item name or designation, page, specific product number, or other available identification.

D. Specific-Category Submittal Requirements

1. General: Except as otherwise indicated in individual work sections, comply with requirements specified herein for each indicated category of submittal.
 - a. Where testing or inspections are specified in individual sections or where Testing or Inspections are required by governing authorities, submit test or inspection reports to the Engineer.
 - b. The requirements for submission of other types of submittals are specified in individual sections.

- c. Submit a detailed description and shop drawings describing how each outlet will be installed and how the cabling will be installed to each outlet. Describe the mounting type, raceway types and paths. Submit to engineer for approval prior to purchasing materials.
 - d. Construction Schedule: Within five (5) days after execution of the Contract or the date of issuance of a letter of intent, whichever is earlier; submit a detailed construction schedule to Engineer. This document will be finalized after submitting it with bid. Include with construction schedule a separate schedule of the following meetings:
 - 1) Project Weekly Progress Meetings: Day of week and time.
 - 2) Other Proposed Meetings: Purpose, Date, and Time for each.
 - e. Section Cross-Reference: Refer to Divisions 01 and 17 for construction schedule requirements.
 - f. Submit a construction schedule with monthly invoice. Indicate:
 - 1) Activities or portions of activities completed up to the end of the previous month.
 - 2) The progress along the critical path in terms of days ahead of or behind the allowable dates.
 - g. The accepted construction schedule shall not be changed without the Owner's consent. In such instance, promptly submit a revised schedule to the Engineer.
2. Shop Drawings
- a. Shop Drawings are drawings, diagrams, schedules and other data specially prepared for the Work by the Contractor, manufacturer, supplier or distributor to illustrate some portion of the Work.
 - b. Provide newly prepared information on project drawings with graphic information at accurate scale, except as otherwise indicated, with name of preparer indicated. Show dimensions and note which are based on field measurement. Identify materials and products for the work shown. Indicate compliance with standards, and coordination requirements. Do not allow shop drawing copies without appropriate final "Action" markings by the Engineer to be used in connection with the work.
 - c. Drawing Requirements: Shop drawings shall indicate dimensions necessary for construction and erection; arrangement and sectional views; complete details including relationship and connection with adjoining work of other trades; kind of materials, thickness and finish, and other data necessary.
 - 1) Identify details by reference to sheet and detail numbers shown on Contract Drawings.
 - 2) Size PDF documents to print and be legible at the following print sizes: Minimum: 18" x 24"; maximum: 30" x 42".
 - d. Related Work: Associated drawings relating to a complete assembly shall be submitted at same time to greatest extent possible, so that each may be checked in relation to proposed assembly. Furnish necessary templates, patterns and setting drawings to other trades as required for coordination.
 - e. Reference Set: Maintain one copy of each accepted set of shop drawings at project site, available for reference by the Engineer and others.

- f. Installer's Copy: Do not proceed with installation of materials, products, or systems until copy of accepted applicable shop drawings is in possession of Installer.
- 3. Product Data
 - a. Product Data are illustrations, standard schedules, performance charts, instructions, brochures, diagrams and other information furnished by the Contractor to illustrate materials or equipment for some portion of the Work.
 - b. General: Collect required data into one submittal for each unit of Work or system; and mark each copy to show which choices and options are applicable to project. Include manufacturer's standard printed recommendations for application and use, compliance with standards, application of labels and seals, notation of field measurements which have been checked, and coordination requirements.
 - 1) Modify drawings and diagrams to delete information which is not applicable to the Work.
 - 2) Supplement standard information to provide information specifically applicable to the Work.
 - 3) Clearly mark each copy to identify pertinent products, brand names or models.
 - 4) Show performance characteristics and capacities.
 - 5) Show dimensions and clearances required.
 - 6) Show wiring or piping diagrams and controls.
 - c. Manufacturer's Standard Specifications: Submit manufacturer's specifications modified to reflect job conditions and project requirements.
 - d. Manufacturer's Required Recommendations: Where specifications sections require manufacturer's recommendations, submit such recommendations with product data.
 - e. Reference Set: Maintain one set of product data (for each submittal) at project site, available for reference by the Engineer, the General Contractor and others.
 - f. Required Copies: Provide a preliminary submittal where required for selection of options by the Engineer.
 - g. Installer's Copy: Do not proceed with the purchase or installation of materials, products or systems until copy of accepted applicable product data is in possession of Installer.
- 4. Inspection and Test Reports: Provide all test reports to the Engineer as specified. All reports to be typed. Submit format for approval prior to commencing test.
- 5. Warranties:
 - a. General: Refer to individual specifications sections for additional requirements on warranties, product/workmanship bonds and maintenance agreements.
 - b. Copies: In addition to copies desired for Contractor's use, furnish one executed copy in each conformed Operation and Maintenance Manual.

6. Close-out Submittals:
 - a. Record Documents: Refer to Division 01.
 - b. Maintenance/Operating Manuals: Refer to Division 01.
 - c. Materials and Tools: Refer to individual work sections for required quantities of spare parts, extra and overrun stock, maintenance tools and devices, keys, and similar physical units to be submitted.
7. Action on Submittals
 - a. Engineer's Action:
 - 1) Where action and return of submittal is specified, Engineer will review each submittal, mark with "Action", and return submittal. Where submittal must be held for coordination, Contractor will be so advised.
 - 2) Unrestricted Release: Work may proceed, provided it complies with Contract Documents, when submittal is returned with the following marking: "No Exceptions Taken".
 - 3) Restricted Release: Work may proceed, provided it complies with notations and corrections on submittal and with Contract Documents, when submittal is returned with the following marking: "Make Corrections Noted."
 - 4) Returned for Resubmittal: Do not proceed with Work. Revise submittal in accordance with notations thereon, and resubmit without delay. Do not allow submittals with the following marking "Rejected – See Remarks" or Submit Specified Item" (or unmarked submittals where a marking is required) to be used in connection with performance of the Work.
 - 5) Other Action: Where submittal is returned for other reasons, Project Engineer will note reason and return it marked as follows: "Action Not Required" or "No Action Taken."
 - 6) Non-Conforming Submission: Submittals which do not comply with Contract Documents shall not be submitted. Should a submission which does not comply with the Contract Documents be forwarded, said submission will be returned without action, marked "Non-Complying Submission."
 - 7) Where submittals are noted as "For Information Only", "For Owner's File", or similar designation, Engineer will accept submittal but will take no action and will not return submittal to Contractor. Submittals including, but not limited to, Inspection and Test Reports, Warranties, Certifications, Standards and Maintenance Manuals and other Close-Out Submittals do not require Engineer's action and will not be returned to Contractor.
 - b. Contractor's Action:
 - 1) Contractor's Review: Prior to submission, check, correct, stamp and sign submission for coordination with Work of other trades, field dimensions and conditions, and for compliance with the Contract Documents. Mechanical and electrical submissions shall bear stamps of acceptance and certification indicating that coordination between mechanical and electrical trades has been carried out and that no conflict exists. Notify in writing of any deviations from Contract Documents, or of any changes required for coordination or field conditions.

- 2) Contractor's Stamp: The Contractor's stamp shall have following wording: "The Contractor certifies that the Shop Drawing or Sample has been reviewed and Work indicated complies with the Contract Documents."
- 3) Contractor's Distribution: When submittals are returned "Accepted for Design", or "Accepted For Design as Noted", the Contractor shall provide reproductions of Shop Drawings and copies of Product Data which carry the Engineer and Contractor's stamp to subcontractors, suppliers, fabricators, installers, governing authorities and others as necessary for performance of Work. Show such distributions on transmittal forms.

E. Submission Procedure

1. In the event that first submission is considered unsatisfactory as to make it unwise for Contractor to proceed with any work indicated, the submission will be marked "Rejected-Resubmit", and returned to Contractor.
2. Second and subsequent submissions shall follow the procedures for a first submission until submission is stamped "Accepted for Design" or "Accepted for Design as Noted."
3. Resubmission: When transparencies are returned as "Rejected-Resubmit", original tracing shall be corrected, a new reproducible transparency made and resubmitted until is obtained.
4. The Contractor shall direct specific attention, in writing, on resubmitted Shop Drawings, Product Data, Samples or similar submittals, to revisions other than those noted by the Engineer on previous submittals.
5. If submittals, upon review by the Owner or Engineer are found not to conform to the requirements of these specifications, the Contractor shall be required to resubmit with modifications. The Contractor shall be responsible for the Owner's extra expenses for subsequent review(s) of rejected submittals necessitated by the Contractor's failure to make the requested modifications. Such extra fees shall be deducted from payments by the Owner to the Contractor. Acceptance of submittals by the Owner or Engineer shall not relieve the Contractor of responsibility to meet the requirements of this Section.

1.9 WARRANTIES

A. General

1. In general, the Contractor shall warrant the Security Systems they are providing for a period of one (1) year after acceptance by the Owner. All materials, equipment, parts and labor are included within the warranty. System failures, faulting operations, system components, parts, etc. shall all be remedied and corrected to 100% satisfaction of the Owner.
2. If any failure or defect occurs within the warranty period, the Manufacturer/ Contractor shall remedy it within 48 hours at no cost to the Owner, or any Owners' Representative or consultant.

B. Provide a warranty certificate at the Project closeout from the Contractor.

PART 2 - PRODUCTS

2.1 GENERAL

- A. In general, all products shall be new and free of any defects.

PART 3 - EXECUTION

3.1 GENERAL

- A. All work shall conform to the standards and codes of the following organizations and publications as applicable. When a conflict occurs, follow the most stringent requirements:
 - 1. NFPA 70 – National Fire Code
 - 2. FCC – Federal Communications Commission
 - 3. NBC – National Building Code (as adopted for site location)
 - 4. NFPA – National Fire Protection Association
 - 5. All local codes and regulations
 - 6. Manufacturers recommendations and requirements
- B. In general, the Security Contractor shall provide a new, complete, certified, tested, and warranted security system as described in the Specifications and Drawings.
- C. The complete installation shall be installed with highly skilled and trained technicians providing a quality and professional system.
- D. Provide a supervisory work force sufficient to efficiently and effectively execute the Contractor's responsibilities.
- E. Generally accepted industry standards, as well as manufacturer's written installation instructions and recommendations, shall be used for in-process quality control and final acceptance of the Work installation.
- F. System and Product Manufacturers: Certified and experienced craft personnel will be required to provide and use the proper tools and test equipment in the performance of each activity. Tools must be in good working order and test equipment must be properly calibrated. Contractor is responsible for safe storage of tools, and is responsible for the security of their tools, materials, and work in place until final acceptance by the Owner.
- G. Cable Placement
 - 1. Adequate care shall be exercised when handling, storing reels, or during the installation of cable to prevent damage to the cable. Do not install cabling with dents, flat spots, or other sheath distortions. Do not leave pulled cable above the floor, susceptible to damage prior to terminating.
 - 2. After pulling cable, coil neatly and tie-up, so it is not lying above the floor.

- H. Securing Cable: Cables and equipment shall be supported and secured as indicated on the Drawings. Where the specific method of support is not shown, adequate supports and fasteners shall be used to secure cable and equipment in position in accordance with Section 27 15 00 Communications Horizontal Cabling. Metallic supports and fasteners shall have a corrosion-resistant finish. All methods used to secure or transport cables shall be in accordance with the applicable codes, standards, and Owner Guidelines.
- I. Damage:
 - 1. The cable shall be carefully inspected for sheath defects or other irregularities as it is comes off the reel. If defects are detected, cable placement shall stop immediately, with the cable section being repaired or replaced at the discretion of the Owner. A system of communications, visual or otherwise, shall be maintained between feed and pulling locations so that pulling can be stopped instantly, if necessary.
 - 2. Ensure that cable is not coated with any foreign material such as paint, drywall mud, etc. through the project duration. Cleaning coatings off cabling (beyond small incidental splatters) is not an acceptable remedy. At Owner's discretion, any cabling found with coatings shall be replaced at no additional cost to Owner.

END OF SECTION

SECTION 28 05 13

CONDUCTORS AND CABLES FOR FIRE ALARM

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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. Coaxial cabling.
 - 2. Fire alarm wire and cable.
 - 3. Fire alarm single mode, 8.2 micrometer, optical fiber cabling.
 - 4. Identification products.

1.3 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. EMI: Electromagnetic interference.
- C. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
- D. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).

- E. RCDD: Registered Communications Distribution Designer.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. For coaxial cable, include the following installation data for each type used:
 - a. Nominal OD.
 - b. Minimum bending radius.
 - c. Maximum pulling tension.
 - 2. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 - 3. Cabling administration drawings and printouts.
 - 4. Wiring diagrams to show typical wiring schematics including the following:
 - a. Cross-connects.
 - b. Patch panels.
 - c. Patch cords.
 - 5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.
- B. Source quality-control reports.
- C. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings by an RCDD.
 2. Installation Supervision: Installation shall be under the direct supervision of Certified Fiber Optic Technician, who shall be present at all times when Work of this Section is performed at Project site.
 3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- B. Testing Agency Qualifications: An NRTL.
1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- 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. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.
- E. Grounding: Comply with ANSI-J-STD-607-A.
- 1.7 DELIVERY, STORAGE, AND HANDLING
- A. Test cables upon receipt at Project site.
1. Test each pair of UTP cable for open and short circuits.
 2. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight.
- 1.8 FIELD CONDITIONS
- A. Do not install conductors and cables that are wet, moisture damaged, or mold damaged.
1. Indications that wire and cables are wet or moisture damaged include, but are not limited to, discoloration and sagging of factory packing materials.
- B. Environmental Limitations: Do not deliver or install UTP, optical fiber, and coaxial cables and connecting materials until wet work in spaces is complete and dry, and

temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.9 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Surface-Burning Characteristics: 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: 450 or less.
- 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 OPTICAL FIBER CABLE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Belden Inc.
 - 2. CommScope, Inc.
 - 3. Corning Incorporated; Corning Cable Systems.
 - 4. General Cable Technologies Corporation.

B. Description: Single-mode, nominal 9/125-micrometer, 6-fiber, nonconductive, tight buffer, optical fiber cable.

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA/EIA-568-B.3 for performance specifications.
 - a. General Purpose, Nonconductive: Type OFN or OFNG.
 - b. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
 - c. Riser Rated, Nonconductive: Type OFNR, complying with UL 1666.
 - d. General Purpose, Conductive: Type OFC or OFCG.
 - e. Plenum Rated, Conductive: Type OFCP, complying with NFPA 262.
 - f. Riser Rated, Conductive: Type OFCR, complying with UL 1666.
3. Conductive cable shall be aluminum armored type.
4. Maximum Attenuation: 8 dB at 1310 nm and 1550 nm end to end with all patch cables installed.
5. Minimum Modal Bandwidth: 500 MHz-km at 1300 nm.

C. Jacket:

1. Jacket Color: Yellow or red.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-C.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

2.3 OPTICAL FIBER CABLE HARDWARE

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

1. ADC.
2. American Technology Systems Industries, Inc.

3. Belden Inc.
4. Berk-Tek; a Nexans company.
5. Corning Incorporated; Corning Cable Systems.
6. CSI Technologies Inc.
7. Dynacom Inc.
8. Hubbell Incorporated; Hubbell Premise Wiring.
9. Molex Premise Networks; a division of Molex, Inc.
10. Siemon.

- B. Cable Connecting Hardware: Meet the Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2-B, TIA-604-3-B, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.

1. Quick-connect, simplex and duplex, Type ST or Type LC connectors as required to match equipment. Insertion loss not more than 0.75 dB.

2.4 COAXIAL CABLE

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

1. Alpha Wire Company.
2. Belden Inc.
3. Coleman Cable, Inc.
4. CommScope, Inc.
5. Draka Cableteq USA.

- B. General Coaxial Cable Requirements: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.

C. RG-11/U: NFPA 70, Type CATV.

1. No. 14 AWG, solid, copper-covered steel conductor.
2. Gas-injected, foam-PE insulation.
3. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.
4. Jacketed with sunlight-resistant, black PVC or PE.
5. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.

D. RG59/U: NFPA 70, Type CATVR.

1. No. 20 AWG, solid, silver-plated, copper-covered steel conductor.
2. Gas-injected, foam-PE insulation.
3. Triple shielded with 100 percent aluminum polyester tape and 95 percent aluminum braid; covered by aluminum foil with grounding strip.
4. Color-coded PVC jacket.

E. RG-6/U: NFPA 70, Type CATV or CM.

1. No. 16 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
2. Double shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid.
3. Jacketed with black PVC or PE.
4. Suitable for indoor installations.

F. RG59/U: NFPA 70, Type CATV.

1. No. 20 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.

2. Double shielded with 100 percent aluminum polyester tape and 40 percent aluminum braid.
3. PVC jacket.

2.5 COAXIAL CABLE HARDWARE

- 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. Emerson Network Power Connectivity Solutions; AIM Electronics Brand.
 2. Leviton Commercial Networks Division.
 3. Siemon.
- B. Coaxial-Cable Connectors: Type BNC, 75 ohms.

2.6 FIRE ALARM WIRE AND CABLE

- A. Basis-of-Design Product: Subject to compliance with requirements, provide products by the following or approved equivalent:
 1. Comtran Corporation.
 2. Draka Cableteq USA.
 3. Genesis Cable Products; Honeywell International, Inc
 4. Rockbestos-Suprenant Cable Corp.
 5. West Penn Wire.
 6. Lake Cable.
- B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760. All wiring shall be in accordance with the manufacturer's preferred recommendations. All wiring shall be solid copper conductors.
- C. Signaling Line Circuits: No. 16 AWG as recommended by system manufacturer.

- D. Notification Appliance Circuits: No. 14 AWG as recommended by system manufacturer.
- E. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.
 - 1. Low-Voltage Circuits: No. 16 AWG, minimum.
 - 2. Line-Voltage Circuits: No. 12 AWG, minimum.

2.7 IDENTIFICATION PRODUCTS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Brady Worldwide, Inc.
 - 2. Hellermann Tyton North America.
 - 3. Kroy LLC.
 - 4. Panduit Corp.
- B. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- C. Comply with requirements in Section 260553 "Identification for Electrical Systems."
- D. All labels shall be type written and laser printed.
- E. All fire alarm devices and appliances shall be labeled with P touch labels with their respective address.
- F. All cables will be labeled with the circuit number at all terminations and junction boxes.

2.8 SOURCE QUALITY CONTROL

- A. Factory sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by

generating a voltage whose frequency is varied through the specified frequency range and graphing the results.

- B. Cable will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for installation of supports for cables.

3.2 WIRING METHOD

- A. Install wiring in metal pathways and wireways.
 - 1. All cabling including fiber optic cable shall be installed in EMT unless otherwise indicated. Minimum conduit size shall be 1 inch. Control and data transmission wiring shall not share conduit with other building wiring systems. 3/4 inch conduit shall be permitted where wiring serves only a single device or appliance.
 - 2. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems"
- B. Install cable, concealed in accessible ceilings, walls, and floors when possible.
- C. Wiring within Enclosures:
 - 1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
 - 2. Install lacing bars and distribution spools.
 - 3. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer.

4. Install conductors parallel with or at right angles to sides and back of enclosure.
5. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks.
6. Mark each terminal according to system's wiring diagrams.
7. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Comply with NECA 1.
- B. Conductors: Size according to system manufacturer's written instructions unless otherwise indicated.
- C. General Requirements for Cabling:
 1. Comply with TIA/EIA-568-B.1.
 2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
 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. 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.
 5. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
 6. 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.

7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
8. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

D. Optical Fiber Cable Installation:

1. Comply with TIA/EIA-568-B.3.
2. Cable may be terminated on connecting hardware that is rack or cabinet mounted. Fusion splices shall be completed to factory terminated assemblies.

E. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-B recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
4. Separation between cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.

- b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
- c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
- 5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
- 6. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.4 FIRE ALARM WIRING INSTALLATION

- A. Comply with NECA 1 and NFPA 72.
- B. Wiring Method: Install wiring in metal raceway according to Section 260533 "Raceways and Boxes for Electrical Systems."
 - 1. Fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated raceway system. This system shall not be used for any other wire or cable.
- C. Wiring Method:
 - 1. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
- D. 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 the fire alarm 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.
- E. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
- F. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Color coding of wire shall be per the Owner's Color Coding Schedule. 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. All conduit fittings shall be red.

- G. Risers: Install at least two vertical cable risers to serve the fire alarm system.

3.5 POWER AND CONTROL-CIRCUIT CONDUCTORS

- A. 120-V Power Wiring: Install according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables" unless otherwise indicated.
- B. Minimum Conductor Sizes:
 - 1. Class 1 remote-control and signal circuits, No. 14 AWG.
 - 2. Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
 - 3. Class 3 low-energy, remote-control, alarm and signal circuits, No. 12 AWG.

3.6 CONNECTIONS

- A. Comply with requirements in Section 283111 "Digital, Addressable Fire-Alarm System for connecting, terminating, and identifying wires and cables.

3.7 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-B, "Firestopping" Annex A.
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.8 GROUNDING

- A. For low-voltage wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.9 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.10 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 2. Coaxial Cable Tests: Comply with requirements in Section 274133 "Master Antenna Television System."
- B. Tests and Inspections:
 - 1. Visually inspect optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
 - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 3. Optical Fiber Cable Tests:
 - a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - b. Link End-to-End Attenuation Tests:
 - 1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
 - 2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.

- C. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide or transfer the data from the instrument to the computer, save as text files, print, and submit.
- D. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

END OF SECTION

SECTION 28 13 00

ACCESS CONTROL SYSTEM

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

- A. The Access Control System (ACS) to be installed as part of the Work shall expand an existing ACS currently in use by the Owner via Local Area Network (LAN) provided by the Owner. The Contractor shall be responsible to provide and install all items necessary for a fully functional and operational system including, but not limited to:
1. Electronic Door Locking Hardware not supplied as part of the Architectural Door Hardware Schedule
 2. Card Readers and Keypads
 3. Door Position Switches
 4. Remote Release Buttons
 5. Request-to-Exit (REX) buttons.
 6. Request-to-Exit (REX) Passive Infrared (PIR) motion sensors.
 7. Card Reader Interface/Field Panels
 8. Control Panels
 9. Power Supplies
 10. Backup Batteries for Lock Power
 11. Access Control Cards
 12. Software (if required for expansion)
 13. Software License(s) (if required for expansion)
 14. Computer Servers (if required for expansion)
 15. Computer Client Workstations
 16. Cables, connectors, conduits, raceways, cable management and all other interconnection devices and supports.
 17. Mounting hardware, brackets, and all other fasteners.
- B. Definitions
1. Credential: Data assigned to an entity and used to identify that entity.
 2. Identifier: A credential card; keypad personal identification number; or code, biometric characteristic, or other unique identification entered as data into the entry-control database for the purpose of identifying an individual. Where this term is presented with an initial capital letter, this definition applies.
 3. Location: A Location on the network having a workstation-to-controller communications link, with additional controllers at the Location connected to the workstation-to-controller link with either a TIA 485-A communications loop or IEEE 802.3 10/100/1000BaseT connection. Where this term is presented with an initial capital letter, this definition applies.
 4. Workstation: Personal computer. Applies to the central station, workstations, and file servers.
 5. RF: Radio frequency.
 6. TCP/IP: Transport control protocol/Internet protocol.

7. Wiegand: Patented magnetic principle that uses specially treated wires embedded in the credential card.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Reference each product to a location on Drawings.
- B. Shop Drawings: Include plans, elevations, sections, details, diagrams, and attachments to other work.
 1. Cable schedules and labeling
 2. Wiring diagrams and typical details
 3. Functional block diagrams
 4. Typical mounting details
 5. Battery and charger calculations.

1.3 INFORMATIONAL SUBMITTALS

- A. ISO9000 listing certificate.
- B. CA and FCC compliance certificates
- C. Field Quality Control (QC) reports
- D. Warranty: Software support and warranty information for all components, including Service Level Agreement (SLA) details, and duration of agreements from date of system acceptance by the Owner.
- E. Current Genetec Integrator Certification Letter
- F. Current Genetec Training Certificates, listing expiration dates, for two (2) technicians from the supporting office.

1.4 CONTRACTOR REQUIREMENTS

- A. The contractor must have:
 1. A supporting office within fifty (50) miles of the project location.
 2. Onsite personnel holding all required local, state, and federal licenses.
 3. Onsite personnel holding current applicable certification with Genetec for installation of the products.
 4. Two (2) technicians holding current applicable certifications with Genetec for service and maintenance of the products.
 5. Onsite maintenance and repair service are available locally within four (4) hours of notification of condition.
- B. Provide three (3) references for completed projects of similar scope.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For all system components including passwords, keys, IP addresses, MAC addresses and as built drawings.
 - 1. Provide all unused products and materials supplied as part of the Work.
 - 2. Provide system recovery files on portable storage media.
 - 3. Provide system backup files on portable storage media.
 - 4. Provide one (1) printed and one (1) electronic copy of project binder. This shall include at a minimum:
 - a. Table of contents
 - b. Contractor's contact information
 - c. List of spare parts
 - d. Datasheets for all equipment
 - e. Operation and Maintenance (O&M) manuals for all equipment.
 - f. Operation and maintenance procedures required but not covered in manufacturer manuals.
 - g. Training syllabus
 - h. Training manual and material(s).

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. Fuses of all kinds, power and electronic, equal to ten (10) percent of amount installed for each size used, but no fewer than three units.
 - 2. Access control cards: minimum of 100.

1.7 QUALITY ASSURANCE

- A. Installation must comply with local, state, and federal codes and direction of the Authority Having Jurisdiction (AHJ).
- B. Contractor supplied electrical components, devices and accessories must be listed and labeled as defined in NFPA 70, by a qualified testing agency and marked for the intended application.
- C. Contractor supplied software and hardware must be programmed and installed in accordance with manufacturer's specifications and recommendations.
- D. Contractor supplied equipment must be new, in current production, and the standard products of a manufacturer of electronic security system equipment.
- E. Manufacturers must guarantee availability of parts for a minimum of seven (7) years from the date of shipment.
- F. Contractor must review and be familiar with all drawings and specifications of the Work.
- G. Software integration between integrated systems must be tested and certified for interoperability by the manufacturer of each system.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Store in temperature- and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature and humidity in accordance with manufacturer recommendations for equipment storage.
- B. Open each container and verify contents against packing list. File copy of packing list, complete with container identification, for inclusion in operation and maintenance data.

1.9 PERMITS

- A. The Contractor is responsible to obtain all required permits for the performance and completion of the Work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. System Software: Genetec
- B. Access Control Panels and Modules: Genetec, or approved equivalent that is compatible with the Genetec access control system.

2.2 DESCRIPTION

- A. Installed equipment shall expand an existing Genetec Enterprise system that is City-Wide in nature.
- B. All software and hardware provided as part of the Work shall be of the latest version available and compatible with the existing ACS. This must include all software upgrades and support for one (1) year from the date of final system acceptance.
- C. Provide software license(s) to enable full system operation at all security system servers and client workstations.
- D. Provide software license(s) to include all doors/card readers, servers, and workstations plus ten (10%) percent for future additions.

2.3 CARD READER

- A. Requirements:
 - 1. Access control card readers shall be manufactured by a global company who is a recognized leader in the production of access control devices. Card readers manufactured for non-access control applications are not acceptable.
 - 2. Multi-technology contactless readers shall be capable of reading access control data from both 125 kHz and 13.56 MHz contactless smart cards and NFC-compatible cards and devices.

3. The multi-technology contactless reader shall be optimally designed for use in access control applications that require reading both 125 kHz Proximity and 13.56 MHz contactless smart cards.
4. Multi-technology contactless readers shall comply with the following 13.56 MHz-related standards to ensure product compatibility and predictability of performance of ISO 14443.
5. Multi-technology contactless reader shall be configurable to read 13.56 MHz data simultaneously from the following cards (multiple credential support based on reader configuration):
 - a. Secure support: MIFARE® DESFire® EV1 with PACSA, MIFARE Classic, FIPS 201 PIV Credential.
 - b. UID/CSN Support: DESFire Classic V0.06, HID iClass, ISOX (my-d).
 - c. Proximity: Schlage Proximity, XID Proximity, HID Prox, AWID, GE/CASI, Prox, Inside Pictotag, TI Tagit, ST Micro.
6. Multi-technology contactless readers shall be configurable to read data from any compatible 125 kHz technology simultaneously with 13.56 MHz data.
7. Multi-technology contactless readers shall provide the ability to read card access data stored in the secure access control sector/application area of the ISO 14443 XceedID MIFARE or MIFARE DESFire EV1 card.
8. The multi-technology contactless reader shall be configurable to provide compatibility with all standard Prox formats up to 37 bits (including Corporate 1000®).
9. Multi-technology contactless readers shall allow the reader firmware to be upgraded in the field without the need to remove the reader from the wall through the use of factory-provided devices.
10. Multi-technology contactless readers shall be suitable for global deployment by meeting worldwide radio and safety regulatory compliance including:
 - a. FCC Certification (US)
 - b. CE (EU)
 - c. C-tick (Australia, New Zealand)
 - d. R&TTE Directive (15EU)
 - e. UL294 (US)
 - f. ULC-S319
 - g. IC (Canada)
 - h. FIPS201 / PIV I
 - i. IP65
11. Multi-technology contactless readers shall be fully compliant with Restriction of Hazardous Substances directive (RoHS) restricting the use of specific hazardous materials found in electrical and electronic products.
12. Multi-technology contactless readers shall provide universal compatibility with most access control systems by outputting card data in compliance with the SIA AC-01 Wiegand standard.
13. Multi-technology contactless readers shall allow for secure installation practices through mounting methods utilizing tamper resistant screws.

14. Multi-technology contactless readers shall provide the ability to transmit an alarm signal via an integrated optical tamper switch if an attempt is made to remove the reader from the wall. The tamper switch shall be programmable to provide a selectable action to provide a selectable action compatible with various tamper communication schemes provided by access control panel manufacturers. The selectable action shall include one of the following:
 - a. The reader open collector line changes from a high state (5V) to a low state (Ground).
 - b. If utilizing OSDP Protocol, readers shall report a tamper condition via RS485.
 15. Multi-technology contactless readers shall be provided with a quick connect wire harness.
 16. Multi-technology contactless reader shall be designed for low current operation to enable migration from most legacy proximity applications without the need to replace existing access control panels and/or power supplies. Contactless smart card power requirements shall be:
 - a. Operating voltage: 5 – 16 VDC, reverse voltage protected. Linear power supply recommended.
 - b. Current requirements: 160 mA DC, 195 mA PEAK @ 12 VDC
 17. Physical Specifications:
 - a. Dimensions : 5.1" x 3.25" x 0.83" (12.9 cm x 8.3 cm x 2.1cm)
 - b. Weight: 9.6 oz. (272.15 g).
 - c. Material: UL94 Polycarbonate.
 - d. Installation: mounted to standard single-gang or double-gang electrical boxes.
 - e. Plastics: Consist of three-piece design with mounting plate, potted case, and aesthetic cover.
 - f. Color: Black, Gray, Brown, or Cream, or as approved by the project architect.
 18. Environmental Specifications:
 - a. Operating temperature: -31 to 151 degrees F (-35 to 67 degrees C)
 - b. Operating humidity: 5% to 95% relative humidity non-condensing
 - c. Weatherized design suitable to withstand harsh environments, with a certified rating of IP65.
 19. Cabling Requirements:
 - a. Cable distance: (Wiegand): 500 feet (150m)
 - b. Cable type: 5-conductor #22 AWG
 - c. Standard reader termination: 18" (0.5m) wire harness
- B. Card reader shall be as follows:
1. Standard: HID Signo40.
 2. Standard with Keypad: HID Signo40K.
 3. Mullion Mount: HID Signo20.

2.4 ACCESS CONTROL SYSTEM UNITS

- A. Description: This category covers head end units for access control systems, providing a means of regulating or controlling physical entry into an area, or access to or use of device by electrical, electronic, and/or mechanical means. Access control systems are investigated as complete configuration based upon manufacturer's specified system components. Access control systems are intended to comply with applicable life safety access and egress requirements.
- B. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70 and NFPA 72, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
 - b. Comply with NFPA 1, NFPA 730, NFPA 731, and ICC IBC.
 - 2. Listing Criteria: UL CCN ALVY, including UL 294.
- C. Access Control System Data Gathering Panels:
 - 1. Specifications:
 - a. Data ports for connection to LAN and downstream DGPs.
 - b. Integral terminal blocks secured to enclosure.
 - c. Enclosure lock with tamper switch and monitoring.
 - d. Integral terminal blocks for connection of inputs/outputs to field devices.
 - e. Controller Inputs:
 - 1) Auxiliary input.
 - 2) Door contact.
 - 3) Request to exit.
 - 4) Cabinet tamper.
 - 5) Power monitor.
 - f. Controller Outputs:
 - 1) Auxiliary output.
 - 2) Door strike.
 - 3) Door operators.
 - 4) Credential readers.
 - g. Input/Output Boards:
 - 1) Inputs:
 - a) Door contact.
 - b) Request to exit.
 - c) Cabinet tamper.
 - d) Power monitor.
 - e) Auxiliary inputs from building systems.

- 2) Outputs:
 - a) Auxiliary outputs to building systems.
 - b) Door strike.
 - c) Credential readers.
 - d) Audible devices.
- 2. Specifications:
 - a. Input Voltage: 120 V(ac)
 - b. Internal Power Supply: 12 V(dc) power supply.
 - c. Operating Temperature: 32 to 158 deg F (0 to 49 deg C).
 - d. Enclosure
 - 1) Size:
 - a) Large: 18.19" w x 21.38" h x 4.56" d.
 - b) Small: 10.38" w x 8.63" h x 2.06" d.
 - 2) Materials: Steel
 - e. Battery Backup: 12 Vdc, providing a minimum of 7 hours backup.
 - f. DGP Communication: IEEE 802.3 10/100/1000BaseT.
 - g. Mounting: Wall mount.
- 3. Manufacturers:
 - a. Genetec.
 - b. Mercury.

2.5 POWER SUPPLIES AND BATTERY CHARGERS

- A. Description: This category covers power supplies and battery chargers for access control system units, controllers, input/output interfaces, workstations, printers, and encoders.
- B. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70 and NFPA 72, by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
 - b. Comply with NFPA 1, NFPA 730, NFPA 731, and ICC IBC.
 - 2. Listing Criteria: UL CCN ALVY; including UL 294.
- C. Access Control System Power Supply:
 - 1. Characteristics:
 - a. Input Voltage: 120 V(ac)
 - b. Output Voltage: 12 or 24 V(dc)
 - c. Operating Temperature: 32 to 120 deg F (0 to 49 deg C)].
 - d. Network connection for remote supervision, management, and testing.
 - e. Enclosure lock with tamper switch and monitoring.

- f. Built-in battery charger.
 - g. Enclosure Size: 12" w x 16" h x 4.5" d.
 - h. Materials: Steel.
 - i. Output Current: 6 A.
 - j. Number of Outputs: 8
 - k. Mounting: Wall mount.
 - 2. Manufacturer: Altronix, or approved equivalent
 - a. Power Supply: Part No. AL600ULACM.
 - b. Rechargeable Battery: Part No. BT1212.
- D. Magnetic Lock Hardware with Special Locking Arrangement for Fire-Rated Doors
 - 1. Performance Criteria:
 - a. Regulatory Requirements:
 - 1) 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) Compliant with NFPA 101, ICC IBC, and local life safety code requirements for use along means of egress.
 - b. Listing Criteria:
 - 1) Special Locking Arrangements: UL CCN FWAX or UL CCN FWAX2; including UL 294, NFPA 101, and ICC IBC.
 - 2) Electromagnetic Locks for Fire-Rated Doors: UL CCN GWXT; including UL 10B and UL 10C.
 - 2. Specifications:
 - a. Input Voltage: 12 to 24 V(dc).
 - b. Holding Force: 1200 lb. force (5338 N).
 - c. Release Delay: Zero seconds.
 - d. Relock Function: Manual relock.
 - e. Door Prop Alarm Delay: 30 seconds.
 - f. Door Movement Detection: 1/8 inch (3 mm).
 - g. Integral door position switch.
 - 3. Manufacturers:
 - a. Locknetics
 - b. Securitron
 - c. Schlage
 - d. Or approved equal.
- E. Request-to-Exit (REX) Motion Sensor
 - 1. Performance Criteria:
 - a. Regulatory Requirements: 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. Listing Criteria: UL CCN ALVY, including UL 294.

2. Specifications:

- a. Input Power: 12 or 24 Vdc.
- b. Operating Temperature: 0 to 120 degrees F.
- c. Sensing Technology: Passive infrared (PIR).
- d. Color: White.
- e. Mounting: Ceiling surface.

3. Manufacturers:

- a. Bosch
- b. Locknetics
- c. Securitron
- d. Or approved equal.

F. Request-to-Exit (REX) Push Button

1. Performance Criteria:

- a. Regulatory Requirements: 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. Listing Criteria: UL CCN ALVY; including UL 294.

2. Specifications:

- a. Input Power: 12 to 24 V(ac/dc).
- b. Operating Temperature: Operating Temperature: 0 to 120 degrees F.
- c. Operating Mechanism: Pneumatic, with adjustable time delay.
- d. Faceplate Material: Stainless steel.
- e. Button Material: Plastic.
- f. Button Color: Red.
- g. Lettering Color: White.
- h. Failure Mode: Fail-Secure.

3. Manufacturers:

- a. Rutherford Controls 991 series.
- b. Or approved equal.

G. MISCELLANEOUS FIELD HARDWARE

- 1. Panic Alarm Push Button shall be ADI Pro 0E-HBMOMSD3T. Contractor shall coordinate with owner to determine call direction when panic button is depressed.
- 2. Door contacts shall be Edwards Signaling 1078C 1" circular magnetic contacts for flush mount and Edwards Signaling 2505 series for surface mount.

H. Cable

- 1. Composite siamese cable with individually jacketed component cables designed to provide connectivity to each device at a door connected to the access control system.
- 2. Overall diameter: 0.542 inches.
- 3. UL-Listed CMP for placement in an air-handling plenum environment.

4. Individual jackets and conductors:
 - a. Card Reader: 3-pair 18-AWG stranded with overall shield, and ORANGE jacket.
 - b. Lock Power: 4-conductor 16-AWG stranded with overall shield and GRAY jacket.
 - c. Door Contact: 2-conductor 18-AWG stranded with overall shield and WHITE jacket.
 - d. Request-to-Exit and Spare: 4-conductor 18-AWG stranded with overall shield and BLUE jacket.
5. Belden Part No. 638AFS or approved equal.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Provide a fully functional and operational system as detailed in these specifications and the contract drawings.
- B. Coordinate all installation activities with other trades.
- C. Utilize industry-standard wiring and grounding practices in accordance with applicable local and national codes and as directed and approved by the Engineer of Record (EOR) and the AHJ.
- D. Follow all local and national life safety and fire codes.
- E. Install the system using skilled workmanship and of acceptable quality as approved by EOR and AHJ.
- F. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
- G. Examine roughing-in for LAN and control cable conduit systems to workstations, controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.
- H. Proceed with installation only after unsatisfactory conditions have been corrected.
- I. Cable splices are not permitted.

3.2 PREPARATION

- A. In meetings with Architect and Owner, present Product Schedules, and review, adjust, and prepare final setup documents. Use approved, final Product Schedules to set up system software.

3.3 IDENTIFICATION

- A. In addition to requirements in this article, comply with applicable requirements in Section 270553 "Identification for Communications Systems" and with ANSI/TIA 606-D, "Administration Standard for Commercial Telecommunications Infrastructure."
- B. Use unique alphanumeric designations for each cable, and label cable and jacks, connectors, and terminals to which it connects with the same designation. Use logical and systematic designations for facility's architectural arrangement.
- C. Label each terminal strip and screw terminal in each panel.
 - 1. All wiring conductors connected to terminal strips shall be individually numbered, and each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with the name and number of the particular device as shown.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at the device if the color of the wire is consistent with the associated wire connected and numbered within the panel or cabinet.

3.4 SYSTEM SOFTWARE AND HARDWARE

- A. Install and test software and hardware, and perform database tests to verify the complete and proper operation of systems involved. Assign software license to Owner.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to supervise and assist with startup service.
 - 1. Complete installation and startup check according to approved procedures that were developed in "Preparation" Article and with manufacturer's written instructions.
 - 2. Enroll and prepare badges and access cards for Owner's operators, management, and security personnel.

3.6 TESTING

- A. The Contractor must perform thorough operational testing and verify that all system components are fully operational.
- B. Submit an Acceptance Test Plan (ATP) for approval to the Construction Manager (CM). The ATP must include a form detailing Pass/Fail criteria and test result for each item under test.
- C. ATP must include procedures for remedy and retest of failed items.
- D. System acceptance will be granted upon successful completion of ATP.

3.7 TRAINING

- A. Engage a factory-authorized representative to train Owner's personnel to adjust, operate, and maintain the ACS. See Section 017900 "Demonstration and Training."
- B. Submit a Training Syllabus for approval to the Construction Manager (CM). The syllabus must include a list of topics to be covered, training materials, and an estimate of the number of hours required to train twelve (12) system operators.
- C. Develop separate training modules for the following:
 - 1. Security personnel.
 - 2. Hardware maintenance personnel.
 - 3. Department management.

END OF SECTION

SECTION 28 15 23

SECURITY INTERCOM AND EMERGENCY CALL SYSTEMS (Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes requirements for providing equipment and materials for an IP Audio and Video Intercom and Emergency Call systems.

1.2 SUBMITTALS

- A. Provide submittal information for the following submittal sections as described below. See Section 28 0050 for additional requirements.
 - 1. Product Data
 - 2. Shop Drawings:
 - a. Floor plans indicating locations of all equipment.
 - b. Wiring Diagrams: Indicate wiring for each item of equipment and interconnections between items of equipment.
 - c. Include manufacturer's names, model numbers, ratings, power requirements, equipment layout, device arrangement, complete wiring point-to-point diagrams, and conduit layouts.

1.3 SYSTEM DESCRIPTION

- A. IP Network Compatible Video Intercom System: A network-based communication and security system featuring video entry security, internal communication, emergency stations, and paging. All units and app in the systems shall be able to unlock doors remotely on a network, assist onsite visitors from an offsite location, broadcast emergency announcements, and communicate using a PoE network.
 - 1. Power Source: Power over Ethernet (802.3af).
 - 2. Network Interface: 10 BASE-T / 100 BASE-TX Ethernet (RJ-45).
 - 3. Network Protocols: IPv4, IPv6, TCP, UDP, SIP, HTTP, HTTPS, MJPEG, RTSP, RTP, RTCP, IGMP, MLD, SMTP, DHCP, NTP, DNS.
 - 4. Bandwidth Usage:
 - a. G.711: 64Kbps x 2 per video call.
 - b. 64Kbps per monitor.
 - c. H.264: 24Kbps ~ 2,048Kbps.
 - 5. Communication: Hands-free (VOX), push-to-talk (simplex), or handset (full-duplex).
 - 6. Video Display: 3-1/2 inches (89 mm) color LCD.
 - 7. Camera: Type:
 - a. 1/4 inch (6 mm) color CMOS.
 - b. View Area: 2 feet 2 inches (660 mm) vertical x 3 feet 1 inch (940 mm) horizontal at 20 inches (508 mm).

8. Video Stream: ONVIF Profile S.
9. Door Release: Programmable Form C dry contact, 24V AC/ DC, 500mA - use EL-12S (use RY-24L for larger contact rating, which requires 24V DC power supply) or use RY-IP44 with 4 multipurpose relays.
10. Wire Type: Category-6.
11. Distance:
 - a. Door Station or RA Station to Network Node: 330 feet (100 meters).
 - b. Master Station to Network Node: 330 feet (100 meters).

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: ISO 9001:2008 certified company.
- B. Installer Qualifications: Factory trained and experienced with system installations of scope and size required for the Project.
- C. Mock-Up: Provide a mock-up for evaluation of surface preparation techniques and application workmanship.
 1. Finish areas designated by Architect.
 2. Do not proceed with remaining work until workmanship is approved by Architect.
 3. Refinish mock-up area as required to produce acceptable work.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly identifying product name and manufacturer.
- B. Storage: Store materials in clean, dry area indoors in accordance with manufacturer's instructions.
- C. Handling: Protect materials during handling and installation to prevent damage.

1.6 PROJECT CONDITIONS

- A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Manufacturer: Aiphone Corp. or Approved Equal
- B. IP Video Intercom System: IX Series Intercom System as manufactured by Aiphone Corporation.

2.2 SYSTEM DESIGN

- A. Master Station(s): Provide master stations as shown on the drawings.
- B. Programmable dry contacts are available at the door station. The contacts are Form C 500mA, 24V AC/DC. Door release wiring from the door station is separate from the network connection to the door station and is not included in this specification. Door strikes and their power sources are not included in this specification. Not available from Aiphone. An amplifier or self-amplified speaker can be connected to the 600 ohm output from any door station to increase outgoing volume. Communication from the door station to the master will still be transmitted from the door station's microphone. Amplifier is not included in this specification. Continuous audio and video to a Network Video Recorder is available. The IP address of the NVR will need to be supplied when programming the door station. The NVR is not included in this specification.
- C. Audio Video Door Stations:
 - 1. Model IX-DA - Surface Mount: as shown on the drawings
 - 2. Model IX-DF with SBX-ISDVF - as shown on the drawings
 - 3. Model IX-DF - Flush Mount: as shown on the drawings Model IX-DF-HID with SBX-ISDVF- Surface Mount with Card Reader
 - 4. Model IX-DMV - Mullion Mount
- D. Provide Selective Door/Gate Release.
- E. Provide Audio/Video streaming via ONVIF Profile S.
- F. Provide ONVIF Profile S camera input (max 50).
- G. Connect to overhead paging.
- H. Provide Contact input at door station.

2.3 FUNCTIONAL COMPONENTS:

- A. As indicated on the drawings or as required to complete system.
 - 1. Video Master Station Model IX-MV:
 - a. An IP addressable video master station with a 3.5 inch (89 mm) color LCD monitor. It can be wall or desk mounted (desk stand included). The IX-MV offers handset (duplex) and hands-free (VOX/PTT) communication and call up to 500 other IX units. This connects directly to a network using Category-6 cable. This station requires a 802.3af compliant Power-over-Ethernet network.

2. Audio/Video Door Station Model IX-DF-2RA:
 - a. Flush mount unit connects to a PoE network using Category-6 cable. The IX-DF-2RA will call up to 20 IX-MV masters or instances of the IX MOBILE. The door station features a stainless steel face plate with two call buttons ("Normal" and "Emergency" Buttons can be programmed to call different master(s)), Braille signage and call placed/answered indication. Additionally, the IX-DF-2RA has a form C contact for door release, two additional relays for auxiliary device control, a 600 ohm output for paging or an amplified speaker, and a contact input.
3. Audio/Video Door Station Model IX-DA:
 - a. Surface mount unit connects to a PoE network using Category-6 cable. The IX-DA will call up to 20 IX-MV masters or Instances of the IX MOBILE. The door station features a form C contact for door release, a 600 ohm output for paging or an amplified speaker, call placed/answered indication, and a contact input.
4. Audio/Video Door Station Model IX-DF:
 - a. Flush mount unit connects to a PoE network using Category-6 cable. The IX-DF will call up to 20 IX-MV masters or instances of the IX MOBILE. The door station features a stainless steel face plate, a form C contact for door release, a 600 ohm output for paging or an amplified speaker, call placed/answered indication, and a contact input.
5. Audio/Video Door Station Model IX-DVM:
 - a. Mullion-mount unit connects to a PoE network using Category-6 cable. The IX-DMV will call up to 20 IX-MV masters or instances of the IX MOBILE. The door station features a stainless steel face plate, a form C contact for door release, a 600 ohm output for paging or an amplified speaker, call placed/answered indication, and a contact input.
6. RY-IP44 IP Programmable Relay Adaptor:
 - a. With 4 contact inputs and 4 relay outputs (compatible with the IX Series, IS-IP Series, and IPW-1A only).
7. Stainless Steel Wall Mount Box Model IS-WBHE & IS-WBHA:
 - a. The box provides an easy-to-see heavy duty enclosure for an IX Series call station, used for Emergency and Assistance applications. Installed in parking garages, airports, campuses, malls, and a wide variety of locales, these stations provide proper signage and specifications to meet ADA requirements. Beacon is always lit for easy visibility; strobe flashes during emergency call-in. ADA (28 CFR Part 36 section 4.4.1) states that an object must not protrude more than 4 inches (102 mm) if mounted higher than 27 inches (686 mm). Since these units have the potential to include a camera, mounting height restrictions are avoided with this streamline design, while call button mounting height guidelines can still be met. Any Aiphone IX RA series station can fit into the wall mount box. Signage is selectable by the customer.

8. Stainless Steel Wall Mount Box Model IS-WBCE & IS-WBCA:
 - a. The box provides an easy-to-see heavy duty enclosure for an IX Series call station, used for Emergency and Assistance applications. Installed in parking garages, airports, campuses, malls, and a wide variety of locales, these stations provide proper signage and specifications to meet ADA requirements. Beacon is always lit for easy visibility; strobe flashes during emergency call-in. ADA (28 CFR Part 36 section 4.4.1) states that an object must not protrude more than 4 inches (102 mm) if mounted higher than 27 inches (686 mm). Since these units have the potential to include a camera, mounting height restrictions are avoided with this streamline design, while call button mounting height guidelines can still be met. Any Aiphone IX RA series station can fit into the wall mount box. Signage is selectable by the customer.
9. Stainless Steel Enclosure Model SBX-ISDVF:
 - a. 18-Gauge stainless steel enclosure designed for surface mounting the IX-DF, IS-SS, IX-DF-HID, and IX-DF-RP10 door stations.
10. Stainless Steel Enclosure Model SBX-ISDVFRA:
 - a. 18-Gauge stainless steel enclosure designed for surface mounting the IX rescue assistance subs. Compatible with the IX RA stations.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive integrated security and communication system.
- B. Notify Architect of conditions that would adversely affect installation or subsequent use.
- C. Do not begin installation until unacceptable conditions are corrected.

3.2 PREPARATION

- A. Verify the following compliance before starting installation.
 1. The unit turns inoperative during power failure.
 2. Keep the intercom wires at least 1 foot (30 cm) away from strong electrical wiring (AC 100-240 V) including, in particular, wiring for inverter electrical appliances. Noise and malfunction could result.
 3. If a strong light shines on the main unit screen, the picture may turn white or only silhouettes will be visible.
 4. Other manufacturer's devices (such as sensors, detectors, and door releases) used with this system shall comply with the manufacturer's installation requirements.
 5. The LCD panel is manufactured with very high precision techniques. Inevitably will have a very small portion of its picture elements always lit or not lit at all. This is not considered a unit malfunction. Please be aware of this in advance.

3.3 INSTALLATION

- A. Install integrated security and communication system in accordance with manufacturer's instructions at locations indicated on the Drawings.
- B. Mount equipment plumb, level, square, and secure. For video entrance stations and video door stations, comply with manufacturer's design requirements to provide optimum picture quality of station monitoring.

3.4 SET-UP AND ADJUSTING

- A. Adjust integrated security and communication system for proper operation in accordance with manufacturer's instructions.

3.5 DEMONSTRATION AND TRAINING

- A. Demonstration:
 - 1. Demonstrate that integrated security and communication system functions properly.
 - 2. Perform demonstration at final system inspection by qualified representative of manufacturer.
- B. Instruction and Training:
 - 1. Provide instruction and training of Owner's personnel as required for operation of integrated security and communication system.
 - 2. Provide hands-on demonstration of operation of system components and complete system, including user-level program changes and functions.
 - 3. Provide instruction and training by qualified representative of manufacturer.

3.6 PROTECTION

- A. Protect installed integrated security and communication system from damage during construction.

END OF SECTION

SECTION 28 20 00

VIDEO SURVEILLANCE SYSTEMS

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

PART 1 - GENERAL

1.1 SUMMARY

- A. The Video Surveillance System (VSS) will provide real-time surveillance and recording. The Contractor shall be responsible to provide and install all items necessary for a fully functional and operational system including, but not limited to:
 - 1. Indoor and Outdoor IP Cameras.
 - 2. Power Supplies (where required).
 - 3. VSS Software.
 - 4. VSS Software License(s).
 - 5. VSS Camera License(s) or Bundle(s).
 - 6. Computer Servers.
 - 7. Client Workstations.
 - 8. Cables, connectors, conduits, raceways, cable management and all other interconnection devices and supports.
 - 9. Mounting hardware, brackets, and all other fasteners.
- B. Definitions
 - 1. AGC: Automatic gain control.
 - 2. B/W: Black and white.
 - 3. CCD: Charge-coupled device.
 - 4. FPS: Frames per Second.
 - 5. FTP: File transfer protocol.
 - 6. IP: Internet protocol.
 - 7. LAN: Local area network.
 - 8. MPEG: Moving picture experts' group.
 - 9. NTSC: National Television System Committee.
 - 10. PC: Personal computer.
 - 11. PTZ: Pan-tilt-zoom.
 - 12. RAID: Redundant array of independent disks.
 - 13. TCP: Transmission control protocol - connects hosts on the Internet.
 - 14. UPS: Uninterruptible power supply.
 - 15. WAN: Wide area network.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Reference each product to a location on Drawings.

- B. Shop Drawings: For video surveillance. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Cable schedules and labeling
 - 2. Wiring diagrams and typical details
 - 3. Functional block diagrams
 - 4. Typical mounting details
 - 5. Battery and charger calculations.

1.3 INFORMATIONAL SUBMITTALS

- A. ISO9000 listing certificate
- B. CA and FCC compliance certificates
- C. Field Quality Control (QC) reports
- D. Warranty: Software support and warranty information for all components, including Service Level Agreement (SLA) details, and duration of agreements from date of system acceptance by the Owner.
- E. Current Milestone Systems Integrator Certification Letter
- F. Current Milestone Systems Training Certificates, listing expiration dates, for two (2) technicians from the supporting office.

1.4 CONTRACTOR REQUIREMENTS

- A. Have a supporting office within fifty (50) miles of the project location.
- B. Have onsite personnel holding all required local, state, and federal licenses.
- C. Have onsite personnel holding current applicable certification with Milestone Systems for installation of the products.
- D. Have two (2) technicians holding current applicable certifications with Milestone Systems for service and maintenance of the products.
- E. Have onsite maintenance and repair service available locally within four (4) hours of notification of condition.
- F. Provide three (3) references for completed projects of similar scope.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For all system components including passwords, keys, IP addresses, MAC addresses and as built drawings.
 - 1. Provide all unused products and materials supplied as part of the Work.
 - 2. System recovery files on portable storage media.
 - 3. System backup files on portable storage media.

4. One (1) printed and one (1) electronic copy of project binder. This shall include at a minimum:
 - a. Table of contents
 - b. Contractor's contact information
 - c. List of spare parts
 - d. Datasheets for all equipment
 - e. Operation and Maintenance (O&M) manuals for all equipment.
 - f. Operation and maintenance procedures required but not covered in manufacturer manuals.
 - g. Training syllabus
 - h. Training manual and material(s).

1.6 QUALITY ASSURANCE

- A. Installation must comply with local, state, and federal codes and direction of the Authority Having Jurisdiction (AHJ).
- B. Contractor supplied electrical components, devices and accessories must be listed and labeled as defined in NFPA 70, by a qualified testing agency and marked for the intended application.
- C. Contractor supplied Software and hardware must be programmed and installed in accordance with manufacturer's specifications and recommendations.
- D. Contractor supplied equipment must be new, in current production, and the standard products of a manufacturer of electronic security system equipment.
- E. Manufacturers must guarantee availability of parts for a minimum of seven (7) years from the date of shipment.
- F. Contractor must review and be familiar with all drawings and specifications of the Work.
- G. Software integration between integrated systems must be tested and certified for interoperability by the manufacturer of each system.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store video surveillance system equipment in temperature- and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature and humidity in accordance with manufacturer recommendations for equipment storage.
- B. Open each container and verify contents against packing list. File copy of packing list, complete with container identification, for inclusion in operation and maintenance data.

1.8 PERMITS

- A. The Contractor is responsible to obtain all required permits for the performance and completion of the Work.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All materials shall be new, UL listed, and free from damage or defects. The contractor shall furnish all materials as listed below and any other materials listed on the drawings or as otherwise required for a complete installation. The Contractor shall furnish any appropriate or recommended material needed for proper installation of the systems. The following is a partial list of materials that are required. Refer to the drawings for further information and requirements.
- B. Provide rack mount assembly for all rack-mounted devices.

2.2 MANUFACTURERS

- A. System Software: Genetec Systems
- B. Network Video Recorders (NVR) & Client Workstations: Genetec Networks
- C. Cameras: Axis Communications

2.3 SYSTEM REQUIREMENTS

- A. All software and hardware provided as part of the Work shall be of the latest version available. This must include all software upgrades and support for one (1) year from the date of final system acceptance.
- B. Provide software license(s) to enable full system operation at all security system servers and client workstations.
- C. Provide software licenses to include all cameras, recorders, servers, and workstations, plus ten (10%) percent for future camera additions.

2.4 CAMERAS

- A. Camera types and quantities as indicated on the contract documents.
 - 1. Interior Fixed IP Color Dome Camera: Axis P3265-LV or approved equal.
 - 2. Interior 360 Degree Multisensor IP Color Dome Camera: Axis P3727-PLE or approved equal.
 - 3. Exterior Fixed IP Color Dome Camera: Axis P3267-LVE or approved equal.
 - 4. Exterior Fixed IP Color Bullet Camera: Axis P1467-LE or approved equal.
 - 5. Exterior 180/270/360 Degree Multidirectional IP Color Dome Camera: Axis P3737-PLE or approved equal.
 - 6. Exterior Pan-Tilt-Zoom IP Color Dome Camera: Axis Q6075-E or approved equal.

2.5 LIGHTNING PROTECTOR DEVICE

- A. Designed to protect outdoor-mounted POE CCTV cameras.

- B. Provide 1 protector device for each wall and parapet-mounted outdoor CCTV camera.
- C. Manufacture: Tripplite, Part No. B110-SP-CAT-OD, or approved equivalent.

2.6 NETWORK VIDEO RECORDERS

- A. Video Recorders shall be Genetec.
- B. Provide NVRs and storage as indicated on the contract documents.
- C. Calculate video storage requirements based on these specifications:

Camera Location	Storage Requirements		
	6 am – 9 pm Weekdays	Sunday-Saturday 6 am – 9 pm	Evenings 9 pm – 6 am
Indoor	No Motion: 1 FPS Motion: 10 FPS	No Motion: 1 FPS Motion: 10 FPS	No Motion: 1 FPS Motion: 10 FPS
Outdoor	No Motion: 1 FPS Motion: 10 FPS	No Motion: 1 FPS Motion: 10 FPS	No Motion: 1 FPS Motion: 10 FPS

Resolution: 5MP or the resolution of the CCTV camera.

2.7 VIDEO SURVEILLANCE SYSTEM SOFTWARE

- A. Genetec

2.8 CLIENT WORKSTATIONS

- A. Provide each workstation with two (2) Samsung model LS24A600UCNXGO 24" S60UA Monitors or approved equal.
- B. Provide two (2) workstations at locations directed by the construction manager.

2.9 UNINTERRUPTABLE POWER SUPPLIES

- A. Provide rack-mounted UPS directly adjacent and dedicated for use with the video recorder/servers. Size UPS for 30 minutes runtime of recorder/server.
- B. Manufacturer: APC, or approved equivalent.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Provide a fully functional and operational system as detailed in these specifications and the contract documents.
- B. Coordinate all installation activities with other trades.
- C. Utilize good wiring and grounding practices in accordance with applicable local and national codes and as directed and approved by the Engineer of Record (EOR) and the AHJ.
- D. Follow all local and national life safety and fire codes.
- E. Install the system using skilled workmanship and of acceptable quality as approved by EOR and AHJ.
- F. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
- G. All Category 6 cabling will be installed by the datacom cabling contractor.
- H. Examine roughing-in for LAN and control cable conduit systems to workstations, controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.
- I. Proceed with installation only after unsatisfactory conditions have been corrected.
- J. Cable splices are not permitted.

3.2 PREPARATION

- A. Comply with TIA 606-D, "Administration Standard for Commercial Telecommunications Infrastructure."
- B. In meetings with Architect and Owner, present Product Schedules, and review, adjust, and prepare final setup documents. Use approved, final Product Schedules to set up system software.

3.3 IDENTIFICATION

- A. In addition to requirements in this article, comply with applicable requirements in Section 270553 "Identification for Communications Systems" and with TIA 606-D.
- B. Use unique alphanumeric designations for each cable, and label cable and jacks, connectors, and terminals to which it connects with the same designation. Use logical and systematic designations for facility's architectural arrangement.
- C. At completion, documentation shall reflect as-built conditions.

3.4 SYSTEM SOFTWARE AND HARDWARE

- A. Install and test software and hardware and perform database tests for the complete and proper operation of systems involved. Assign software license to Owner.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to supervise and assist with startup service.
 - 1. Complete installation and startup check according to approved procedures that were developed in "Preparation" Article and with manufacturer's written instructions.
 - 2. Assign IP addresses as directed by the Construction Manager (CM) in keeping with the Owner's IP address scheme.
 - 3. Name cameras in system software as directed by the Construction Manager (CM) in keeping with the Owner's camera naming scheme.

3.6 TESTING

- A. The Contractor must perform thorough operational testing and verify that all system components are fully operational.
- B. Submit an Acceptance Test Plan (ATP) for approval to the Construction Manager (CM). The ATP must include a form detailing Pass/Fail criteria and test result for each item under test.
- C. ATP must include procedures for remedy and retest of failed items.
- D. System acceptance to be granted upon successful completion of ATP.

3.7 ADJUSTING

- A. Occupancy Adjustments: When requested within twelve (12) months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two (2) visits to Project during other-than-normal occupancy hours for this purpose. Tasks shall include, but are not limited to, the following:
 - 1. Check cable connections.
 - 2. Check proper operation of cameras and lenses. Verify operation of auto-iris lenses and adjust back-focus as needed.
 - 3. Adjust all preset positions; consult Owner's personnel.
 - 4. Recommend changes to cameras, lenses, and associated equipment to improve Owner's use of video surveillance system.
 - 5. Provide a written report of adjustments and recommendations.

3.8 CLEANING

- A. Clean installed items using methods and materials recommended in writing by manufacturer.

- B. Clean video-surveillance-system components, including camera-housing windows, lenses, and monitor screens.

3.9 TRAINING

- A. Engage a factory-authorized representative to train Owner's personnel to adjust, operate, and maintain the VSS. See Section 017900 "Demonstration and Training."
- B. Submit a Training Syllabus for approval to the Construction Manager (CM). The syllabus must include a list of topics to be covered, training materials, and an estimate of the number of hours required to train twelve (12) system operators.
- C. Develop separate training modules for the following:
 - 1. Security personnel.
 - 2. Hardware maintenance personnel.
 - 3. Corporate management.

END OF SECTION

SECTION 28 31 11

DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

(Part of Work of Section 26 00 01 – ELECTRICAL, Trade Bid Required)

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. Fire-alarm control unit.
- 2. Manual fire-alarm boxes.
- 3. System smoke detectors.
- 4. Heat detectors.
- 5. Notification appliances.
- 6. Magnetic door holders.
- 7. Remote annunciator.
- 8. Addressable interface device.
- 9. Notification appliance remote power supply.
- 10. Digital alarm communicator transmitter.

11. Terminal cabinets.
12. Equipment guards.
13. Transient voltage surge suppressors.
14. Exterior beacon.
15. Bypass switch.
16. Fire alarm wiring and cabling.
17. Fire alarm conduit and raceways.

B. Related Requirements:

1. Section 260533 "Raceways and Boxes for Electrical Systems"
2. Section 280513 "Conductors and Cables for Fire Alarm"

1.3 APPLICABLE CODES AND STANDARDS

- A. The specifications and standards listed below form a part of this section of the specifications. The system shall fully comply with the latest issue, with all updates, of these standards as applicable. Where these standards conflict with other specified requirements, the most restrictive requirement shall govern.

1. Underwriters Laboratories, Inc.
2. NFPA Standards 70, Massachusetts Electric Code
3. NFPA 72 National Fire Alarm and Signaling Code
4. NFPA 101 Life Safety Code
5. NFPA 92 Standard for Smoke Control Systems
6. NFPA 241 Standard for Safeguarding Construction, Alteration, and Demolition Operations
7. Massachusetts State Building Code
8. Americans with Disabilities Act (ADA)

9. ANSI: American National Standards Institute.
10. ASTM: American Society for Testing and Materials
11. ICEA: Insulated Cable Engineers Association
12. IEEE: Institute of Electrical and Electronic Engineers
13. NEMA: National Electrical Manufacturers Association
14. Comply with the requirements of the local water department.

1.4 SEQUENCING AND SCHEDULING

- A. Existing Fire alarm equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. When new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Perform a full end to end integrated test in conjunction with NFPA 4, prior to removal of labels. Remove labels from new equipment when put into service.

1.5 DEFINITIONS

- A. ASD: Aspirating Smoke Detection.
- B. EMT: Electrical Metallic Tubing.
- C. EOL: End of Line.
- D. EOLR: End of Line Resistor.
- E. FAA: Fire Alarm Annunciator.
- F. FACU: Fire Alarm Control Unit.
- G. FATC: Fire Alarm Terminal Cabinet.
- H. FPL: Fire Power Limited Cable.
- I. IDC: Initiating Device Circuit.
- J. LED: Light-Emitting Diode.

- K. HLI: High Level Interface.
- L. NAC: Notification Appliance Circuit.
- M. NEMA: National Electrical Manufacturer's Association.
- N. NFPA: National Fire Protection Association.
- O. NICET: National Institute for Certification in Engineering Technologies.
- P. NRTL: Nationally Recognized Testing Laboratory.
- Q. SLC: Signaling Line Circuit.
- R. TVSS: Transient Voltage Surge Suppression.
- S. UPS: Uninterrupted Power Supply.
- T. Words in the singular shall also mean and include the plural, wherever the context so indicates and words in the plural shall mean the singular, wherever the context so indicates.
- U. Wherever the terms "shown on drawings" are used in the specifications, they shall mean "noted", "indicated", "scheduled", "detailed", or any other diagrammatic or written reference made on the drawings.
- V. Wherever the term "provide" is used in the specifications it will mean "furnish" and "install", "connect", "apply", "erect", "construct", or similar terms, unless otherwise indicated in the specifications.
- W. Wherever the term "material" is used in the specifications it will mean any "product", "equipment", "device", "assembly", or "item" required under the Contract, as indicated by trade or brand name, manufacturer's name, standard specification reference or other description.
- X. The terms "approved", or "approval" shall mean the written approval of the Engineer. These terms do not relieve the Contractor from the requirements of the contract documents.
- Y. The term "specification" shall mean all information contained in the bound or unbound volume, including all "Contract Documents" defined therein, including all drawings.

- Z. The terms "directed", "required", "permitted", "ordered", "designated", "prescribed" and similar words shall mean the direction, requirement, permission, order, designation or prescription of the Engineer. The terms "approved", "acceptable", "satisfactory" and similar words shall mean approved by, acceptable or satisfactory to the Engineer. The terms "necessary", "responsible", "proper", "correct" and similar words shall mean necessary, reasonable, proper or correct in the judgment of the Engineer.
- AA. "Concealed" means hidden from sight in chases, furred spaces, shafts, hung ceilings, embedded in construction or in crawl spaces. For wiring purposes use the definition of concealed as provided by NFPA 70.
- BB. "Exposed" means not installed underground or "concealed" as defined above.
- CC. "Fire Alarm Contractor or Contractor" refers to the Contractor and/or his Subcontractors responsible for furnishing and installing all of the work indicated in the Specifications and as shown on the contract drawings.
- DD. "Owner" shall refer to Worcester Fire, and "Engineer" shall refer to Arup.
- EE. The "Fire Alarm System" shall include fire alarm and notification systems.
- FF. Definitions of terms such as alarm, supervisory, and trouble signals shall be those indicated in the applicable paragraphs of the NFPA standards.

1.6 SYSTEM DESCRIPTION

- A. General:
 - 1. An existing fully addressable fire alarm system shall be amended, installed and provided as described herein and on the contract drawings. The system shall include all wiring, raceways, pull boxes, terminal cabinets, outlet and mounting boxes, control equipment (as necessary), alarm, supervisory signal initiating devices, alarm notification appliances, programming and all other accessories and miscellaneous items necessary for a complete operating system even though each item is not specifically mentioned or described.
 - 2. All tamper, waterflow and pressure switches shall be provided with a separate address. All control valves affecting the operation of a fire protection system shall be individually electrically supervised. Each tamper, waterflow and pressure switches shall be provided with a separate address.

3. Interface with the elevator system to initiate recall and activate the firefighter's hat.
4. Report all signals from the fire alarm system to the supervising system as indicated on the drawings.

1.7 PERFORMANCE REQUIREMENTS

- A. The extent of the fire alarm system work is mostly shown on the Contract Drawings and contained in the Specifications. The Specifications supplement the drawings and, therefore, include items of work which are not detailed on the drawings. Submission of a proposal shall be evidence that this contractor has reviewed all Contract Documents and performed all necessary walk downs to determine the complete scope of work.
- B. The Contractor is directed to examine all Contract Drawings in detail. Failure of the Contractor to examine all areas (various ceiling configurations, stair arrangements, pipe racks, cable trays, equipment configurations, etc.), which may require special considerations and misinterpretation of the contract documents resulting there from, shall be entirely his/her responsibility.
- C. Fire alarm and notification systems shall be installed mostly as shown on the Contract Drawings with design criteria as specified in this Section. However, the Contractor shall note that this specification requires the Contractor to prepare and submit drawings, system schematics, calculations, and any other documents needed for the procurement of approvals and the provision of a complete, functional and approved fire alarm system. As a result, the Contract Drawings serve the purpose of indicating design criteria for the Contractor's use and guidance in preparing the required submittal documents for review.
- D. The Contract Drawings and specifications form complimentary requirements. Provide work specified and not shown, and work shown and not specified as though explicitly required by both. Although work is not specifically shown or specified, provide supplementary or miscellaneous items, appurtenances, devices and materials necessary for a sound, secure, complete and approved installation. Completely coordinate work of this specification with work of other trades and existing conditions.
- E. The Contractor shall bring to the attention of the Engineer any conflicts between these drawings and codes or standards for resolution. The Contractor shall not discuss these matters with the Building or Fire Official without the approval of the Owner and Engineer.

- F. Should the Contractor perform any work that does not comply with the requirements of the specifications, drawings and applicable codes, standards and references, the Contractor shall bear all costs arising in correcting the work to the satisfaction of the Engineer.
- G. The Contractor shall include costs to fully complete all the systems including all interconnecting, coordination and installation details and components and extending the system into and throughout all spaces. Contractor shall also include costs for startup, pre-testing, third party testing and acceptance testing, for making all the systems fully operational, for providing all warranties and design contingencies.
- H. Provide contract cost breakdown in accordance with other sections of this specification and submit a breakdown of material and labor costs to the Engineer. Separate unit costs for addition of devices and deletion of devices shall be required as part of the contractors bid.
- I. The Contractor will be required to prepare shop drawings as specified herein. This information, in the form of a single "Package", shall be submitted to the Engineer for review prior to fabrication and installation. The "Package" shall bear approval or listing of a testing laboratory approved by the Fire Department and the Owner's Insurer prior to submission to Engineer for his review.
- J. Give all notices, file all plans and other documents, obtain all permits and all licenses, pay all fees and obtain all approvals from all Authorities Having Jurisdiction as required to perform work in accordance with all requirements and with the Specifications and Contract Drawings, all of which are considered a part of these Contract Documents.
- K. The contractor shall follow NFPA 241: Standard for Safeguarding Construction, Alteration and Demolition Operations and FM Global Property Loss Prevention Data Sheet 1-0, 'Safeguards During Construction, Alteration, and Demolition' during construction.

1.8 ACTION SUBMITTALS

- A. Product Data: For each type of product, including furnished options and accessories.
 - 1. Partial submittals will not be acceptable and will be returned without review.

2. Latest published manufacturer's data sheets; installation instructions; and inspection, testing, and maintenance document shall be provided in electronic copy.
 3. Data sheets shall include the specific make and model of the equipment being provided. Where more than one model is included on the documents, the contractor shall clearly indicate which model is being submitted. If the model is not clearly marked, the equipment submittal may be rejected.
 4. Include construction details, material descriptions, dimensions, profiles, and finishes.
 5. Include rated capacities, operating characteristics, and electrical characteristics.
 6. Manufacturer's data shall be annotated and provided for the following:
 - a. Fire Alarm Control Unit including all components (for any new panels)
 - b. Amplifiers (for any new amplifiers)
 - c. Batteries (as necessary based on updated battery calculations)
 - d. Terminal cabinets
 - e. Manual pull stations
 - f. Smoke detectors
 - g. Heat detectors
 - h. Duct smoke detectors
 - i. Notification appliances (strobes, horns, horn/strobes etc.)
 - j. Graphic annunciator
 - k. Remote power supplies
 - l. Terminal cabinets
 - m. Power conditioner
 - n. Addressable device labels
 - o. Electromagnetic door holders
 - p. Remote LED indicators
 - q. All other associated equipment.
- B. Shop Drawings: For fire-alarm system.
1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the following.

2. Shop drawings shall be drawn to an indicated scale, on sheets of uniform size, with a plan of each floor. The scale shall be no less than 1/8 inch equals 1 foot.
3. Shop drawings shall include the following information:
 - a. Name of protected premises and owner
 - b. Name of installer or contractor
 - c. Location of protected premises
 - d. Device legend in accordance with the owner
 - e. Date of issue and any revision dates
4. Include plans, elevations, sections, details, and attachments to other work.
5. Floor plan drawings shall be drawn to an indicated scale and shall include the following information:
 - a. Floor or level identification.
 - b. Point of compass (indication of North).
 - c. Graphic scale.
 - d. All walls and doors.
 - e. All partitions extending to within 10 percent of the ceiling height.
 - f. Room and area descriptions.
 - g. System device/component locations (i.e. control units, devices, appliances, terminal cabinets, annunciators, etc.).
 - h. Locations of fire alarm primary power connections.
 - i. Locations of monitor/control interfaces to other systems.
 - j. System riser locations.
 - k. Conduit routing, type, and trade size.
 - l. Type and number of system components/devices on each circuit, on each floor or level.
 - m. Type and quantity of conductors and conduit used for each circuit.
 - n. Location of all supply and return air diffusers (where automatic detection is used).
 - o. Identification of any ceiling over 10 feet in height where automatic fire detection is being proposed.
 - p. Final reflected ceiling plans including details of ceiling geometries, beams, and solid joists, where automatic fire detection is being proposed.
 - q. Circuit designation and address for each addressable device. The purpose or function of control and/or monitor modules shall be clearly identified on the floor plans.
 - r. Circuit designation for each notification appliance.

- s. Audible output in watts for each audible notification appliance.
 - t. Visual output in candela for each visual notification appliance.
6. Riser Diagrams. System riser diagrams shall be coordinated with the floor plans and shall include the following information:
- a. General arrangement of the system in building cross section.
 - b. Number of risers.
 - c. Type and number of circuits in each riser.
 - d. Type and number of system components/devices on each circuit, on each floor or level.
 - e. Type, and quantity of conductors and conduit for each circuit.
 - f. Riser diagrams shall indicate all devices and appliances located on the plan drawings along with all circuits.
 - g. Riser diagrams shall indicate the address for each addressable device or appliance located on the plan drawings.
7. Control Unit Diagrams: Control unit wiring diagrams shall be provided for all control equipment (i.e., equipment listed as either a control unit or control unit accessory), power supplies, battery chargers, and annunciators and shall include the following information:
- a. Identification of the control equipment depicted.
 - b. Location(s).
 - c. All field wiring terminals and terminal identifications.
 - d. All circuits connected to field wiring terminals and circuit identifications.
 - e. All indicators and manual controls, including the full text of all labels.
 - f. All field connections to supervising station signaling equipment, releasing equipment, and fire safety control interfaces, where provided.
 - g. All switches and LEDs labeled on each control unit.
8. Typical Wiring Diagrams. Typical wiring diagrams shall be provided for all initiating devices, notification appliances, remote indicators, annunciators, and end-of-line and power supervisory devices.
9. Input/Output Matrix of Operation. An input/output matrix of operation shall be provided with all shop drawings.
10. Calculations. System calculations shall be included with shop drawings as follows:
- a. Primary power supply calculations.

- b. Battery calculations.
 - c. Loop resistance calculations.
 - d. Notification Appliance circuit voltage drop calculations.
 - e. Conduit Fill: Provide a table for the type, size and quantity of conductors and conduit for each circuit.
 - f. Others required.
- 11. 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.
 - 12. Detail assembly and support requirements.
 - 13. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
 - 14. Include performance parameters and installation details for each detector.
 - 15. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
 - 16. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.
 - a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
 - b. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' control system.
 - c. Locate detectors according to manufacturer's written recommendations.
 - d. Show air-sampling detector pipe routing.
 - 17. Include alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
 - 18. 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.

- C. Primary Power Supply Calculations (including all remote power supplies): Provide primary power supply calculations for all system components in accordance with the equipment manufacturers requirements and the following:
1. Calculations shall assume that all SLC cards are fully loaded.
 2. Calculations shall assume all notification appliances are loaded to their maximum RMS current rating per designated strobe and/or horn setting for each notification appliance with an additional 20% increase in total spare load.
 3. Calculations shall demonstrate each individual circuit card, including its 20% increase in total spare load per circuit, is not loaded beyond 90% of its capacity.
 4. Calculations shall demonstrate that the total load, including its 20% increase in total spare load, for each power supply is 90% or less of its full load capacity.
- D. Secondary Power Supply Calculations: Provide secondary power supply calculations for all system components in accordance with the equipment manufacturers requirements and the following:
1. Calculations shall assume that all SLC cards are fully loaded.
 2. Calculate standby battery requirements per manufacturer's installation requirements including all factors for aging, etc.
 3. The secondary power supply shall include standby batteries with a capacity for 24-hours standby operation plus 15-minutes for full building alarm.
 4. Notification circuits shall include a 20% increase in loads per circuit.
 5. Calculations shall indicate the battery capacity is 30% above the combined standby and alarm value.
 6. Battery calculations shall demonstrate stand-by power capacity, and the ability to operate visible notification appliances (strobes, horns and horn/strobes) with the required voltage for the required time-period.
 7. Provide a complete list of the current requirements during normal, supervisory, trouble and alarm conditions for each component of the system.

- E. Voltage Drop Calculations. Provide voltage drop calculations for all notification appliance circuits in accordance with the equipment manufacturers requirements and the following:
1. The lump sum method shall be the calculation method utilized (all appliances shall be assumed at the end of the circuit).
 2. The wire length for Class A circuits shall be the entire length of the circuit. The load shall be permitted to be located at any location on the circuit.
 3. Voltage drop calculations shall indicate a starting voltage of the cut out voltage of the equipment. The starting voltage shall not exceed 20.4 VDC.
 4. Calculations shall utilize the maximum RMS current rating per the strobe setting that is indicated for each notification appliance.
 5. Calculations shall account for an additional 20% increase in total load and wire length (in accordance with the Primary Power Supply Calculations, the total load including the 20% increase shall not exceed 90% of the total power supply capacity and individual circuit card capacity). Spare capacity shall be maintained until system accepted.
 6. The total voltage drop shall be within the limits of the equipment served by the circuit.
 7. The maximum circuit length shall exceed each individual estimated circuit length (including its 20% increase in wire length) by a safety margin of 10%.
 8. Resistances for wires shall be in accordance with the National Electric Code at a temperature of 122°F.
 9. Provide circuit reference number as indicated on the plan drawings, wire distance, wire size, resistance, minimum voltage per circuit, current requirements per circuit and percent of load capacity.
 10. The maximum permitted cable lengths and resistance for each circuit including all increases.
- F. Air Sampling Smoke Detection Calculations:
1. Provide calculations indicating the maximum air sample transport time from the farthest sampling port to the detector does not exceed 100 seconds.

2. Provide calculations indicating the sampling hole sizes.
3. Provide calculations indicating the detector alarm threshold for the maximum UL permitted visible smoke obscuration.
4. Provide electronic file of calculations.

G. General Submittal Requirements:

1. Submittals shall be approved by the owner and engineer prior to submitting them to the authorities having jurisdiction.

1.9 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Seismic Qualification Certificates: For fire-alarm control unit, 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.
- D. Points List: A complete list of device addresses and their corresponding descriptor. The points list shall be provided in Microsoft Excel format. The points list shall be provided to the Engineer and Owner for review at least four weeks prior to beginning the acceptance testing of the fire alarm system. The contractor shall be responsible for completing all modifications to the fire alarm system program. The descriptions shall be updated if necessary, during the testing process.

1.10 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fire-alarm systems 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. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
 3. Record copy of site-specific software.
 4. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
 - a. Equipment tested.
 - b. Frequency of testing of installed components.
 - c. Frequency of inspection of installed components.
 - d. Requirements and recommendations related to results of maintenance.
 - e. Manufacturer's user training manuals.
 5. Manufacturer's required maintenance related to system warranty requirements.
 6. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.
- B. As-built drawings: Provide certified shop drawings at least two (2) weeks before the final system walkthrough. The drawings shall show the system as installed, including deviations from both the project drawings and approved shop drawings.
1. An as-built cabinet shall be provided, and one set of the as-built drawings shall be provided in the cabinet.

1.11 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. Replaceable Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than 6 units of each type.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
3. Smoke Detectors and Heat Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than two units of each type.
4. Manual Fire Alarm Boxes: Quantity equal to 10 percent of amount of each type installed, but no fewer than 2 units of each type.
5. Addressable module: Quantity equal to 10 percent of amount of each type installed, but no fewer than 2 units of each type.
6. Audible and Visual Notification Appliances: 10 percent of each type installed but no fewer than 2 units of each type.
7. Keys and Tools: 6 extra sets for access to locked or tamperproofed components.
8. Fuses: 6 of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.
9. Filters for Air-Sampling Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.

1.12 QUALITY ASSURANCE

- A. Shop Drawings and Calculations: The shop drawings and calculations shall be prepared by an individual with the following qualifications:
 1. Technician that is certified NICET Level III or IV, or a registered fire protection engineer.
 2. Trained and certified by manufacturer in fire-alarm system design.
 3. Licensed or certified by authorities having jurisdiction.
- B. Installer Qualifications: The person performing the installation shall meet the following minimum qualifications:

1. Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
 2. Installation shall be by personnel certified by NICET as fire-alarm Level III or IV technician.
- C. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer.
- D. 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.
- E. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL.
1. Upon completion of the installation the fire alarm system, the contractor shall have the fire alarm installation superintendent furnish copies of the NFPA 72 Fire Alarm Inspection and Testing Form.
 2. Upon completion of the installation, the Fire Alarm Superintendent shall post a certificate of installation in or near the control panel.
- F. This specification identifies the essential functional requirements of the Fire Alarm Systems. Each manufacturer's equipment (hardware and software) and system configuration shall comply with or exceed the functional intent of this specification.
- G. Each component of the Fire Alarm System shall be listed as a compatible product of a single fire alarm system manufacturer under the appropriate category by Underwriters' Laboratories, Inc. (UL), and shall bear the "UL" label. All control equipment shall be listed under UL category UOJZ Control Units System as a single unit.
- H. The fire alarm equipment furnished shall be provided by a Fire Alarm System Supplier who has been providing this type of equipment for the past five years.
- I. Installation shall be in accordance with the applicable edition and provisions of the equipment manufacturers' guidelines.
- J. The system shall be tested in accordance with the following:
1. NFPA 72.
 2. The equipment manufacturers' guidelines.

- K. Through-Penetration Fire Stop Systems shall be listed by Underwriters Laboratories, Inc., for Compliance with UL 1479 "Fire Tests of Through-Penetration Fire-stops".
- L. Bidder Qualifications: The Contractor shall provide proof of competence for both the company and the individual foreman assigned to this project in terms of installing fire detection, alarm and control systems for at least five years which is deemed acceptable to the Engineer and is licensed and registered by the State of Connecticut to install and service fire alarm and detection systems. Confirmation by photocopy of license and certificate of registration shall be submitted.
 - 1. The Contractor shall have on his staff an installation superintendent and under whose direct supervision the approved fire alarm and fire detection system will be installed and tested. The installation superintendent shall be present during all installation and testing.
 - 2. The Contractors shall document their record of complete, satisfactory installation of fire detection, alarm, and control systems.
 - 3. Distributors of acceptable manufacturers' equipment shall provide documentation indicating that they are authorized by the manufacturer to distribute and service the equipment and that they have satisfactorily completed all training courses offered by the manufacturer relating to the equipment provided.

1.13 SOFTWARE SERVICE AGREEMENT

- A. Comply with UL 864, 9th edition or later.
- B. Technical Support: Beginning with Substantial Completion, provide software support for two years.
- C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
 - 1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.14 WARRANTY

- A. The installation shall be warranted for a period of one year. Service on the system or replacement of defective parts shall be provided at no expense to the Owner during this warranty period. The warranty period shall begin the day the fire alarm system is approved and accepted by the Owner. Owner's acceptance will be when the system is installed and tested, (as witnessed by the Owner and Engineer), accepted by the Authority Having Jurisdiction, and the Owner has received all necessary documentation.
- B. The Contractor shall be on site to initiate the repair within 2 hours, 24 hours a day, seven days a week including all holidays.
- C. Nuisance Alarms
 - 1. A nuisance alarm is considered an alarm caused by mechanical failure, malfunction, improper installation, or any alarm activated by a cause that cannot be determined.
 - 2. If the during the warranty period, the Owner experiences more than one nuisance alarm for each 50 input devices connected to the fire alarm system or a single device as a source of two or more nuisance alarms within a continuous six month period, the Contractor shall be responsible for providing the necessary labor, materials, and technical support to correct the problem.
- D. SUBSTITUTIONS
 - 1. Contractors wishing to provide any other product other than that which is specified must follow the following procedures prior to bidding the project. Failure to do so will be cause for rejection of bid.
 - 2. With the bid submission the contractor shall provide a list of any exceptions to the requirements of this specification and identify the section numbers being referenced.
 - 3. Once awarded, deviations shall not be permitted unless a product has been discontinued and is not available. Any deviations to the requirements of this specification shall be approved in writing by the Engineer and Owner's Representative.
 - 4. The Contractor shall functionally demonstrate that the proposed substituted products are, in fact, equal in function, quality, and performance to those specified herein. Such evidence of applicability of any substitute materials

must be submitted to, and accepted by, the Engineer and the Owner's Representative, not less than (10) working days prior to the scheduled submissions of bids.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by Autocall.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

- A. Operation of the fire alarm system shall be in accordance with the Input/Output Matrix of Operations shown on the contract drawings.

2.3 FIRE-ALARM CONTROL UNIT

- A. General Requirements for Fire-Alarm Control Unit:
 - 1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL. Basis of design is the Autocall 4100ES.
 - a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
 - b. Include a real-time clock for time annotation of events on the event recorder and printer.
 - c. Support a minimum of four SLCs per FACU.
 - d. Support a minimum of 120 devices per loop.
 - 2. Addressable Initiation Device Circuits: The FACU shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
 - a. Smoke sensors shall additionally communicate sensitivity setting and allow for adjustment of sensitivity at fire-alarm control unit.
 - b. Temperature sensors shall additionally test for and communicate the sensitivity range of the device.

3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACU shall be listed for releasing service.
 4. Keys: Fire Alarm Control Units shall be keyed with a Hudson Cam Lock B-key or equal and match all terminal cabinets.
- B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
1. Annunciator and Display: Liquid-crystal type, 640 characters, minimum.
 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.
- C. Circuits:
1. FACU, remote amplifier, and remote annunciator communication circuits: NFPA 72, Class X, Survivability Level 1.
 2. Notification Appliance Circuits: NFPA 72, Class A, Survivability Level 1.
 - a. A minimum of two audible and visual notification circuits shall be provided per floor.
 3. Signaling Line Circuits: NFPA 72, Class X, Survivability Level 1.
 - a. Use no more than 75% available addressable devices on each signaling line circuit.
 - b. A minimum of one isolated circuit shall be provided for each floor, unless otherwise indicated on the drawings.
 4. Initiating Device Circuits: NFPA 72, Class B, Survivability Level 1.
 - a. No more than one input shall be connected to an initiating device circuit.
- D. Notification-Appliance Circuit:
1. Operation shall sound a pre-recorded message in accordance with the fire alarm operational matrix provided in the drawings.
 2. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

3. Visible notification appliances shall be addressable.
- E. Elevator Recall:
1. Elevator recall shall be initiated in accordance with the fire alarm operational matrix provided in the drawings.
 2. Elevator controller shall be programmed to move the cars to the alternate recall floor if lobby detectors located on the designated recall floors are activated.
- F. Door Controls:
1. Door hold-open devices shall be released in accordance with the fire alarm operational matrix provided in the drawings.
 2. The fire alarm system shall be interfaced with the security system in order to unlock secured egress doors in accordance with the fire alarm operational matrix provided in the drawings.
- G. Remote Smoke-Detector Sensitivity Adjustment: Controls shall 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.
- H. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station. The fire alarm system shall provide the following information to the supervising station:
1. Device description from fire alarm system.
 2. Device address.
 3. Device type/category (i.e. smoke detector, pull station, waterflow, valve tamper, etc.)
 4. Fire alarm system shall transmit signals to a UL listed central station via a traditional DACT.
 5. Fire alarm system shall also be networked with the existing campus network via a fiber modem.

- I. 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 all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.
- J. Primary Power: 24-VDC obtained from 120-VAC service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals, and supervisory and digital alarm communicator transmitters shall be powered by 24-VDC source.
 - 1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.
- K. Secondary Power: 24-VDC supply system with batteries, automatic battery charger, and automatic transfer switch.
 - 1. Batteries: Sealed lead acid.
- L. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.
- M. Digital Alarm Communicator Transmitter (DACT): The fire alarm system shall be programmed to transmit a unique address for each system component to a UL listed Central Station. The DACT shall be programmed to output signals in the Contact ID format.

2.4 MANUAL FIRE-ALARM BOXES

- A. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
 - 1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.

2. Station Reset: Key- or wrench-operated switch.

2.5 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-VDC, nominal.
2. Detectors shall be two-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
 - a. Rate-of-rise temperature characteristic of combination smoke- and heat-detection units shall be selectable at fire-alarm control unit for 15 or 20 deg F per minute.
 - b. Fixed-temperature sensing characteristic of combination smoke- and heat-detection units shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F.
 - c. Multiple levels of detection sensitivity for each sensor.
 - d. Sensitivity levels based on time of day.

B. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
 2. An operator at fire-alarm control unit, having the designated access level, shall 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.).
- C. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
 2. An operator at fire-alarm control unit, having the designated access level, shall 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.).
 3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
 4. Each sensor shall have multiple levels of detection sensitivity.
 5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
 6. Duct detectors shall be provided with a remote LED alarm indicator and test switch where the LED is not visible from the walking surface.

7. Duct detectors shall be provided with a PAM relay to operate the dampers or shut down AHU's and DOAS'.

2.6 HEAT DETECTORS

- A. General Requirements for Heat Detectors: Comply with UL 521.
 1. Temperature sensors shall test for and communicate the sensitivity range of the device.
- B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.
 1. Mounting: Adapter plate for outlet box mounting.
 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.7 NOTIFICATION APPLIANCES

- A. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.
 1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.
 2. Audibility shall be required to be met in accordance with NFPA 72.
 3. Notification appliances shall be labeled with the word "FIRE."
- B. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. Visible notification appliances shall be the addressable type.
 1. Rated Light Output:
 - a. 15/30/75/110 cd, selectable in the field.
 2. Mounting: Wall or ceiling mounted as indicated.

3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
4. Flashing shall be in a temporal pattern, synchronized with other units.
5. Strobe Leads: Factory connected to screw terminals.
6. Mounting Faceplate: Factory finished, white. Confirm final finish with architect.

C. Tone Notification Appliances:

1. Appliances shall comply with UL 1480 and shall be listed and labeled by an NRTL.
2. Rated for the following outputs: 1/4 to 2 watts at a minimum
3. Mounting: Flush.
4. Matching Transformers: Tap range matched to acoustical environment of horn location. Audible notification appliances shall operate at a 70.7 VRMS input voltage. Provide white faceplate unless otherwise indicated by architect.
5. Audibility throughout all occupied spaces shall be required to be at least 60 dBA minimum, but not less than 15 dBA above the ambient sound level in accordance with NFPA 72.

2.8 MAGNETIC DOOR HOLDERS

- A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.
1. Electromagnets: Require no more than 3 W to develop 25-lbf holding force.
 2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
 3. Rating: 24-VDC.
- B. Material and Finish: Match door hardware.

2.9 REMOTE ANNUNCIATOR PANEL

- A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
- B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals. Remote annunciator shall be equipped with voice paging capabilities and a microphone to match the fire alarm control unit. All bypass switches, display screen and controls shall also match the fire alarm control unit. Each annunciator shall be equipped with an indicator to indicate which microphone is active.

2.10 ADDRESSABLE INTERFACE DEVICE

- A. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.
- B. Integral Relay: Control Module capable of providing a direct signal to elevator controller to initiate elevator recall, initiate HVAC shutdown and closing of smoke dampers, interface with access control system, activation of stair pressurization systems, or other equipment.
- C. Addressable monitor modules shall be provided with an LED that displays a normal condition indicating that the monitor module is operational and in regular communication with the control unit.

2.11 AUXILIARY RELAY

- A. Manufacturer: Air Products and Controls, Inc. or equivalent.
- B. Auxiliary relays shall be listed under UL category UOXX, System Control Unit Accessories.
- C. Operated via an addressable control module and used for circuits requiring more current than the control module's listing.
- D. Auxiliary relays shall be rated at 10 A minimum.

- E. LED for status indication.

2.12 NOTIFICATION APPLIANCE REMOTE POWER SUPPLY

- A. The remote power supply extender panels shall be listed to UL1481 for Power Supplies for Fire Protective Signal Systems.
- B. The remote power supply extender panels shall provide filtered and electronically regulated outputs.
- C. The remote power supply extender panels shall have short circuit and thermal overload protection. The number of remote power supplies on any individual SLC shall comply with the manufacturer's requirements.
- D. Retain one of two transmitter articles below if Project requires alarm and transmission of alarm, supervisory, and trouble signals to a remote alarm receiving station or another remote location.

2.13 DIGITAL ALARM COMMUNICATOR TRANSMITTER

- A. Digital alarm communicator transmitter shall be acceptable to the remote central station, shall comply with UL 632, and shall be listed and labeled by an NRTL.
- B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture one telephone line and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.
- C. Local functions and display at the digital alarm communicator transmitter shall include the following:
 - 1. Verification that both telephone lines are available.
 - 2. Programming device.
 - 3. LED display.

4. Manual test report function and manual transmission clear indication.
 5. Communications failure with the central station or fire-alarm control unit.
- D. Digital data transmission shall be in accordance with the fire alarm operational matrix provided in the drawings and include the following.
1. Address of the alarm-initiating device.
 2. Address of the supervisory signal.
 3. Address of the trouble-initiating device.
 4. Loss of ac supply.
 5. Loss of power.
 6. Low battery.
 7. Abnormal test signal.
 8. Communication bus failure.
- E. Secondary Power: Integral rechargeable battery and automatic charger.
- F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.14 TERMINAL CABINETS

- A. All terminal cabinets shall be 16-gauge steel painted red and marked "Fire Alarm Terminal cabinet, manufactured by Space Age."
- B. Keys: All terminal cabinet doors shall be lockable by key. The key shall be the same as the Fire Alarm Control Unit.

2.15 EQUIPMENT GUARDS

- A. Description: For all equipment except manual fire alarm boxes, welded wire mesh of size and shape for the smoke detector, strobe, horn, horn/strobe, or other device requiring protection.

1. Factory fabricated and furnished by manufacturer of device.

2. Finish: Paint color to match the protected device.

B. Descriptions: For manual fire alarm boxes, clear polycarbonate cover with instructions to activate the fire alarm.

2.16 TRANSIENT VOLTAGE SURGE SUPPRESSORS (TVSS)

A. All fire alarm control units and remote power supplies shall be installed with a Transient Voltage Surge Suppressor (TVSS) that meets the following:

1. Manufacturer: Ditek model DTK-TSS4; Space Age Electronics model E120V ECLIPS Brand; or approved equal.
2. The silicon surge suppressor for 120 VAC, 15 amp lines.
3. The TVSS shall have a minimum 330 V protection level, a minimum 700 A surge current rating, and a maximum response time of <5 nanoseconds.
4. The TVSS shall be listed for a signaling device.
5. The TVSS shall be installed in the manufacturer's approved enclosure.

2.17 EMERGENCY RESPONDER RADIO COVERAGE SYSTEM

A. 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. Retest the existing system once walls are substantially completed. Update and/or add additional antenna locations as necessary to meet the performance criteria below.

B. 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.

- b. The emergency responder radio coverage system installation and components shall also comply with all applicable federal regulations including, but not limited to, FCC 47 CFR Part 90.219.

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, is not permitted to be used as the antenna.
- 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.
- g. There must not be any interference with any other public safety and police bands.

2.18 BYPASS SWITCH

- A. The bypass switch shall be key operated. The key shall not permit access to the fire alarm system cabinets.
- B. The switch shall be momentary and shall not be capable of being locked in the bypass position.
- C. An LED indicator shall be integral with the switch. The LED shall be controlled and powered by the fire alarm system to indicate the bypass is active.

2.19 FIRE ALARM WIRING & CABLING

- A. Comply with section 280513 – “Conductors and Cables for Fire Alarm”

2.20 FIRE ALARM CONDUIT AND RACEWAYS

- A. Comply with section 260533 – “Raceways and Boxes for Electrical Systems.”

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 EQUIPMENT INSTALLATION

- A. Comply with NFPA 72 and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all 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 all other trades have completed cleanup shall be replaced.
 - 2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

- B. Install equipment in accordance with the manufacturer's published installation instructions.
- C. Fire-Alarm Control Unit: Semi-flush mounted, with tops of cabinets not more than 72 inches above the finished floor.
- D. Annunciator: Install with top of panel not more than 72 inches above the finished floor.
- E. Equipment Mounting: Install fire-alarm control unit per the manufacturer's published installation instructions with tops of cabinets not more than 72 inches above the finished floor.
- F. Each fire alarm control unit shall be connected to a dedicated branch circuit, sized as required for proper service. The circuits shall be labeled "Fire Alarm."
 - 1. Connect circuits to receptacle panels served from the generator.
- G. Shielded Cable
 - 1. Where shielded cable is required, all exposed shields shall be protected with heat shrinkable tubing to provide insulation and prevent ground faults.
- H. Ceiling Mounted Equipment: Where possible, devices and appliances installed in acoustic ceiling tiles shall be installed in the center of the tile. For ceiling tiles with the dimensions of 2 feet by 4 feet, devices and appliances are permitted to be installed in the quarter point of the maximum dimension.
- I. Smoke- or Heat-Detector Spacing
 - 1. Comply with NFPA 72, "Smoke-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for smoke-detector spacing.
 - 2. Comply with NFPA 72, "Heat-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for heat-detector spacing.
 - 3. Smooth ceiling spacing shall not exceed a nominal spacing of 30 feet.
 - 4. Smoke detectors shall be installed such that all points on the ceiling have a smoke detector within 21 feet (0.7 times the nominal distance).
 - 5. Detectors shall not be installed above high voltage equipment.

6. HVAC: Locate detectors not closer than 3 feet from air-supply diffuser or return-air opening.
 7. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture.
 8. Fire Alarm Equipment: A smoke detector shall be installed within 21 feet of the fire alarm control units, fire alarm annunciators and remote power supplies.
- J. Signaling Line Circuits
1. The manufacturers recommended cable type that permits the maximum distance shall be used for all signaling circuits, i.e. if a shield permits a maximum allowable distance of 2,000 feet and a non-shielded cable permits a maximum distance of 10,000 feet, the non-shielded cable shall be provided.
- K. Addressable Interface Device: Every addressable interface device connected to a set of contacts shall be assigned a unique address.
1. A single addressable interface will not be permitted to monitor a flow and tamper switch unless the device can monitor multiple circuits. Sub addresses are acceptable.
 2. An auxiliary relays shall be provided for any circuit controlled by an addressable control interface device when the load exceeds 50% of the rating for the control module. An auxiliary relay shall be provided for any control circuit that shuts down or activates a fan.
- L. Manual Fire Alarm Boxes: Locate the operable part of each manual fire alarm box in accordance with NFPA 72, and located on the handle side of each exit door whenever possible.
1. The mounting height of the manual fire alarm boxes shall be consistent throughout the building.
- M. Duct Smoke Detectors: Comply with NFPA 72. Install sampling tubes so they extend the full width of duct.
- N. Remote Status and Alarm Indicators: Install near each device (smoke detector, heat detector, waterflow switch, tamper switch, etc.) that is not readily visible from normal viewing position or located above the ceiling. A single remote status and

alarm indicator is permitted to be shared for a water flow and tamper switch in locations where each device is within 6 feet and visible from a single location.

- O. Audible Notification Appliance: Install wall mounted appliances not less than 6 inches below the ceiling. Install notification appliances on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.
- P. Device Location-Indicating Lights: Locate in public space near the device they monitor.
- Q. Notification Appliance Remote Power Supply:
 - 1. The remote power supply extender panels shall automatically transfer to the battery secondary power supply with no loss of signals during the transfer of power.
 - 2. The remote power supply shall be monitored for trouble conditions and controlled from a fire alarm control unit.
 - 3. Keys shall be keyed the same as the key lock to all of the fire alarm cabinets.
 - 4. No more than five remote power supplies shall be located on any SLC or as recommended by the manufacturer, whichever is more restrictive.
- R. Transient Voltage Surge Suppressors:
 - 1. All TVSSs shall be mounted within a separate enclosure such as a fire alarm terminal cabinet and not within an FACU or remote power supply enclosure.
 - 2. A single TVSS may be permitted to be used for common FACUs or common Remote power supplies within a single room.
- S. End of Line Resistors: Where end of line resistors are used, the resistors shall be located in the floor terminal cabinet at the riser. EOLRs shall be permitted to be installed in the enclosure of the device being monitored to supervise the wiring to a single device.
- T. Door Holder Circuits:
 - 1. The door holders shall be released immediately on fire alarm. On loss of power the doors shall be released after a delay as specified on the sequence of operations.

2. Each set of door holders is not required to be individually controlled. All of the door holders are permitted to be controlled from a single location.
3. Auxiliary relays shall be provided for all circuits where the maximum load exceeds 50% of the rating of the control device (i.e. addressable control module or fire alarm control unit relay).
4. Door holders shall be powered from a 24 VDC circuit from the fire alarm system.

U. Transmission of Signals to the Supervising Station

1. All signals from the fire alarm system shall be individually transmitted to the supervising station by each individual device address.
2. The Contractor shall be responsible for configuring the supervising station software so that all signals are received, and the device location message matches the message displayed on the fire alarm system operator interface.

3.3 CONDUIT/RACEWAY SYSTEM

A. Comply with requirements of section 260533 "Raceways and Boxes for Electrical Systems" and the following requirements:

1. All cabling shall be installed in electrical metallic tubing (EMT) unless otherwise indicated. Minimum conduit size shall be 3/4 inch. Control and data transmission wiring shall not share conduit with other building wiring systems. 1/2 inch conduit shall be permitted where wiring serves only a single device or appliance.
2. Conduit fill shall not exceed the lesser requirements of the NEC or the following:
 - a. Risers and distribution conduits shall not exceed 28.6%. All conduits installed in a corridor and serving more than 10 device and appliances shall be considered a distribution conduit.
 - b. All other conduits shall not exceed 33.3%.
3. Cable must be separated from any open conductors of power, or Class 1 circuits, and will not be placed in any conduit, junction box or raceway containing these conductors.

4. Conduit penetrations shall enter FACUs, remote power supplies, battery enclosures etc., only in Manufacturer recommended locations. Conduit shall not enter any FACU or other remote mounted control panel equipment or backbox on the bottom of the enclosure.
5. Where possible, all raceways shall be concealed. The amount of exposed raceway shall be minimized.
6. All junction box covers shall be painted red to identify raceways used for fire alarm.
7. All conduit fittings shall be painted red.

3.4 FIRE ALARM WIRING AND CABLING

- A. Comply with the requirements of section 280513 "Conductors and Cables for Electronic Safety and Security" and the following requirements:
 1. Wiring shall be completely installed, field connections made and tested for stray voltage, short circuits, and ground faults prior to connection to the intelligent modules.
 2. Fire alarm wiring and cabling shall be continuous between control units, devices, and appliances.

3.5 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 a supervised interface device to the following devices and systems. Install the interface device less than 3 feet from the device controlled for all devices that are not fail safe. Make an addressable confirmation connection when such feedback is available at the 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 atrium smoke control system
 3. Smoke detectors in air ducts of designated HVAC duct systems.
 4. Magnetically held-open doors.
 5. Security system interface.
 6. Alarm-initiating connection to elevator recall system and components.
 7. Alarm-initiating connection to activate emergency lighting control.
 8. Supervisory connections at valve supervisory switches.
 9. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
 10. Supervisory connections at preaction systems.
 11. Supervisory connections at special suppression systems.
 12. Data communication circuits for connection to building management system.
- C. Wire and cable connections to equipment shall use set screw wire connectors, terminal blocks or screw terminals. Twist on wire connectors (wire nuts) and crimp type connectors are not acceptable.

3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and the following requirements:
1. All loop wiring and cabling shall be labeled with laser printer P-touch labels indicating the feed and return for all cabling located at the fire alarm control units, transponders, and terminal cabinets.
 2. A signaling circuit shall be identified with the circuit number at all terminations at individual devices.

3. All addressable devices shall be labeled with laser printer labels indicating their device address and the FACU that serves that device.
 4. All notification appliances will be labeled indicating their circuit and appliance number with a laser printed label.
 5. All cables shall be labeled with the circuit number at all terminations and junction boxes.
 6. All batteries shall be labeled with laser printer labels indicating the installation date when batteries were first energized and the required replacement date per the manufacturer's recommendations.
 7. Each addressable device shall be labeled with a permanent label indicating the device's address.
 8. All FACUs and remote power supplies shall be provided with a label on the inside cover indicating the location of the circuit breaker.
 9. All Notification Appliance Remote Power Supplies shall be equipped with a laser printer label indicating Fire Alarm NAC Panel Number, on the outside of the enclosure
- B. Install framed instructions in a location visible from fire-alarm control unit.

3.7 GROUNDING

- A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.
- B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.8 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly.

3.9 PROJECT CONDITIONS

- A. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

3.10 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by the owner or the owner's representative and the authorities having jurisdiction.
- 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. Perform the following tests and inspections:
 - 1. Visual Inspection: Conduct visual inspection prior to testing.
 - a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
 - b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
 - 2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - 3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4. Submit audibility test reports. Where audibility is not met, additional audible notification appliances shall be installed with no cost to the owner in accordance with section 2.7.

4. Test visible appliances for the public operating mode according to manufacturer's written instructions.
5. Additional Testing Requirements:
 - a. Provide documentation for stray voltage between installation conducts and installation conductors and ground in VAC and VDC.
 - b. Provide documentation for ground fault for each installation conductors, all conductors shall test free of grounds unless intentionally grounded.
 - c. Provide documentation for short circuits between installation conductors, all conductors shall test free of shorts unless shorted by design.
 - d. Provide documentation for loop resistance of all circuits, all measurements shall be less than the calculated resistance. Any circuit with a resistance greater than the calculated value shall be corrected and if the resistance value exceeds the calculated value, revised calculations shall be provided.
 - e. Supervision of the circuits shall be verified and a minimum of 10% of the devices and appliances shall be tested by introducing a fault on the circuit.
 - f. A series of tests to confirm fire alarm normal and emergency power, grounding, circuit protection and other wiring is required. Testing of the battery capacity including a full load test shall be conducted in accordance with NFPA 72.
 - g. Duct detectors shall be tested in accordance with NFPA 72 and the manufacturer's instructions. Pressure readings shall be measured through the use of a manometer in accordance with manufacturer requirements and results shall be submitted.
 - h. Each initiating device shall be functionally tested in accordance with NFPA 72 and each device shall be verified for proper labeling and functionally in accordance with the input-output matrix.
 - i. The contractor should bring to the attention of the Owner any room numbers that are missing in the building prior to fire department testing.
 - j. Functional testing of interfaced systems is required to be tested and documented. The Contractor shall coordinate with the Owner access to the interfaced systems. The interfaced systems include but not limited to the following:
 - 1) Elevator recall
 - 2) Auxiliary relays
 - 3) Smoke door release
 - 4) Override switches

- 5) Bypass switches
 - 6) Fan control and fan override systems
 - 7) Connection to the supervising station
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
 7. The device descriptions for all new fire alarm equipment shall match the signage that is provided for each room.
 8. Confirm all smoke damper closures that are initiated by the fire alarm system are closed by the new interfaces.
 9. The system testing shall be documented, and the following shall be provided:
 - a. As built drawings of the system
 - b. Signed record of completion
 - c. Copy of the test log results
 - d. A complete copy of the points list
 - e. A final copy of the input/output matrix of operation that describes the sequence of operation in editable XLS form
 - E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
 - F. Fire-alarm system will be considered defective if it does not pass tests and inspections.
 - G. Prepare test and inspection reports.
 - H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.
 - I. The Contractor shall repeat the tests as requested by the Engineer and AHJ to demonstrate operation of the fire alarm system. The Engineer will require the fire alarm system to be demonstrated to the Engineer prior to the demonstration to the AHJ.

- J. 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. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system. Two different sessions on non-concurrent days shall be provided. A minimum of two four-hour sessions shall be provided for a minimum of 4 individuals.

3.12 CLEAN-UP

- A. Following completion of the installation and progressively during the course of installation. The contractor shall remove all trash, debris, and surplus material occasioned by this operation so that at all times the environment presents a safe, neat and orderly condition conducive to other activities.
- B. Clean work prior to concealing, painting and acceptance. Perform in stages if directed.
- C. Painted or exposed work that is soiled or damaged: Clean and repair to match adjoining work before final acceptance. Project shall not be considered complete until painting and patching conditions are accepted by the owner.
- D. Remove debris from inside and outside of materials and equipment.
- E. Clean out interiors of all panels.

END OF SECTION

SECTION 31 00 00

EARTHWORK

PART 1 - GENERAL

1.1 WORK INCLUDED

The Contractor shall make excavations of normal depth in earth for trenches and structures, shall backfill and compact such excavations to the extent necessary, shall furnish the necessary material and construct embankments and fills, and shall make miscellaneous earth excavations and do miscellaneous grading.

1.2 RELATED WORK

- A. Section 00 31 00 AVAILABLE PROJECT INFORMATION
- B. Section 31 05 19.13, GEOTEXTILE FABRICS
- C. Section 31 23 19, DEWATERING
- D. Section 31 25 00, EROSION AND SEDIMENTATION CONTROL
- E. Section 31 50 00, SUPPORT OF EXCAVATION
- F. Section 32 12 00, PAVING
- G. Section 32 32 13, CAST-IN-PLACE CONCRETE RETAINING WALL
- H. Section 32 91 19, LOAMING AND SEEDING

1.3 REFERENCES

ASTM International (ASTM)

ASTM	C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
ASTM	D1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft ³) (2700 kN-m/m ³)
ASTM	D2216	Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM	D2487	Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM	D6913	Standard Test Methods Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

ASTM D6938 Standard Test Methods for In-Place Density and Water Content of Soil and Soil-aggregate by Nuclear Methods (Shallow Depth).

Massachusetts Department of Transportation (MassDOT) Standard Specifications for Highways and Bridges.

Code of Massachusetts Regulations (CMR) 310.40.0032 Contaminated Media and Contaminated Debris

Code of Massachusetts Regulations (CMR) 520 CMR 14.00 Excavation & Trench Safety Regulation

1.4 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF GENERAL SPECIFICATIONS, SUBMIT THE FOLLOWING:

- A. Material Test Reports: From a qualified independent testing agency indicating and interpreting test results for compliance of the following with requirements indicated:
 - 1. Classification according to ASTM D 2487 and moisture content according to ASTM D 2216 of each on-site and borrow soil and/or fill material proposed for fill and backfill.
 - 2. Laboratory compaction curve according to ASTM D 1557 for each onsite and borrow soil and/or fill material proposed for fill and backfill.
- B. Supply and Quality Control Inspection Results: Submit the results of all sources of supply and quality control inspections and tests. No work shall be performed until the Owner's Engineer has reviewed the source of supply. It is the Contractor's responsibility to submit the Supply and Quality Control Inspection Results in a timely manner to assure the project's workflow.
 - 1. Certification statements and analytical results for each earth material proposed for fill and backfill proposed to be imported onto the site, including but not limited to crushed stone, loam, bedding sand, gravel sub-base, common fill and structural backfill. At a minimum, the certification shall state the point of origin, its past usage, name of the qualified firm and analytical laboratory that performed the material sampling and testing, and that the material is free of contaminants and do not contain contaminants that exceed the reportable concentrations (RCS-1) of the MCP. The certification shall include representative sample analysis from each point of origin of backfill to be used on the site. The sample(s) shall be analyzed by a certified laboratory for total metals (EPA priority pollutant metals), volatile organic compounds (EPA Method 8260), semi-volatile organic compounds (EPA Method 8270), petroleum hydrocarbons (EPA Method 8100), and Total PCBs and pesticides (EPA Method 8081 and 8082).
 - a. All sampling of soils for chemical testing shall be performed by a person experienced in sample collection and shall be either: 1) a Licensed Site Professional registered in the Commonwealth of Massachusetts; 2) a Professional Engineer registered in the Commonwealth of Massachusetts; 3) a professional Geologist registered in the Commonwealth of Massachusetts; 4) a certified groundwater/environmental professional; or 5) an authorized representative of the one of the persons listed above. Samples of each material shall be submitted to a chemical analytical laboratory, certified by the Massachusetts Department of Environmental Protection.
 - b. Material shall not contain asbestos.

2. Submit additional samples and geotechnical and analytical test data and certifications for every 1,000 cubic yards (every 500 cubic yards for moisture density curves) of material imported or reused on-site or anytime consistency of material changes in the opinion of the Owner's Engineer. Submit associated chemical laboratory data on the imported materials throughout the course of the Work, if requested by the Owner's Engineer, to evaluate the consistency of the source or process, at no additional cost to the Owner.
 3. Information identifying the name of the accredited field and laboratory soil testing subcontractor proposed for documenting conformance of earthwork activities. Include examples of typical field and laboratory test result documentation from the subcontractor that are proposed for use the project. In addition to test results, the report documentation shall include the location and elevation of all tests, materials tested, a description of methods and equipment used, compaction requirements, and conformance or non-conformance. All measuring and testing equipment (MTE) used at the site shall have documentation certifying the MTE has been calibrated within the last year (or sooner if required by subcontractor quality procedures). Calibration certificates shall be provided to the Engineer at least one week prior to MTE use on site.
- C. During Construction, submit written confirmation of fill lift thickness, in-place soil moisture content, and percentage of compaction to the Owner's Engineer before placing the next lift or constructing foundations or structures.

1.5 PROTECTION OF EXISTING PROPERTY

- A. The work shall be executed in such manner as to prevent any damage to facilities at the site and adjacent property and existing improvements, such as but not limited to streets, curbs, paving, service utility lines, structures, monuments, benchmarks, observation wells, and other public or private property. Protect existing improvements from damage caused by settlement, lateral movements, undermining, washout and other hazards created by earthwork operations.
- B. In case of any damage or injury caused in the performance of the work, the Contractor shall, at its own expense, make good such damage or injury to the satisfaction of, and without cost to, the Owner. Existing roads, sidewalks, and curbs damaged during the project work shall be repaired or replaced to at least the condition that existed at the start of operations. The Contractor shall replace, at its own cost, existing benchmarks, observation wells, monuments, and other reference points, which are disturbed or destroyed.
- C. Buried drainage structures and pipes, observation wells and piezometers, including those which project less than eighteen inches (18") above grade, which are subject to damage from construction equipment shall be clearly marked to indicate the hazard. Markers shall indicate limits of danger areas, by means which will be clearly visible to operators of trucks and other construction equipment and shall be maintained at all times until completion of project.

1.6 DRAINAGE

- A. The Contractor shall provide, at its own expense, adequate drainage facilities to complete all work items in an acceptable manner. Drainage shall be done in a manner so that runoff will not adversely affect construction procedures or cause excessive disturbance of underlying natural ground or abutting properties.

1.7 FROST PROTECTION AND SNOW REMOVAL

- A. The Contractor shall, at its own expense, keep earthwork operations clear and free of accumulations of snow as required to carry out the work.
- B. The Contractor shall protect the subgrade beneath new structures and pipes from frost penetration when freezing temperatures are expected.

1.8 GEOTECHNICAL FIELD AND LABORATORY TESTING

The Contractor shall retain the services of a qualified, independent testing agency to conduct the laboratory analyses and field testing of soil materials required by this specification. Coordinate locations and types of field tests to be performed with the Engineer and cooperate in every way with the Engineer and testing laboratory during field testing and with collection of soil samples for laboratory testing.

PART 2 - PRODUCTS

2.1 MATERIALS

A. GRAVEL BORROW:

Gravel Borrow shall satisfy the requirements listed in MassDOT Specification Section M1.03.0, Type b.

B. DENSE GRADED CRUSHED STONE:

Dense Graded Crushed Stone shall satisfy the requirements listed in MassDOT Specification Section M2.01.7.

C. CRUSHED STONE:

Crushed stone shall satisfy the requirements listed in MassDOT Specification Section M2.01.0 (3/4-inch crushed stone) unless otherwise required. Crushed stone shall be placed where gravel stone, compacted gravel stone, or granular fill is identified on the drawings.

C. SAND BORROW:

Sand Borrow shall satisfy the requirements listed in MassDOT Specification Section M1.04.0.

D. PEASTONE:

Peastone shall be smooth, hard, naturally occurring, rounded stone meeting the following gradation requirements:

Passing 5/8 inch square sieve opening	-	100%
Passing No. 8 sieve opening	-	0%

E. BACKFILL MATERIALS:

1. Class B Backfill:

Class B backfill shall be granular, well graded friable soil; free of rubbish, ice, snow, tree stumps, roots, clay and organic matter; with 30 percent or less passing the No. 200 sieve; no stone greater than two-third (2/3) loose lift thickness, or six inches, whichever is smaller.

2. Select Backfill:

Select backfill shall be granular, well graded friable soil, free of rubbish, ice, snow, tree stumps, roots, clay and organic matter, and other deleterious or organic material; graded within the following limits:

<u>Sieve Size</u>	<u>Percent Finer by Weight</u>
3"	100
No. 10	30-95
No. 40	10-70
No. 200	0-10

3. Structural Fill:

Structural Fill shall satisfy the requirements of Gravel Borrow or Dense Graded Crushed Stone, above.

4. Compacted Backfill:

Gravel Borrow shall be placed below pavements and buildings. Class B Backfill shall be placed in landscaped areas.

G. SPECIAL PIPE BEDDING MATERIAL:

The special pipe bedding material shall consist of a filter fabric installed on the trench bottom before backfilling with crushed stone as specified and as shown on the contract drawings. Filter fabric shall be as specified in Section 31 05 19.13, GEOTEXTILE FABRICS.

PART 3 - EXECUTION

3.1 DISTURBANCE OF EXCAVATED AND FILLED AREAS DURING CONSTRUCTION:

- A. Contractor shall take the necessary steps to avoid disturbance of subgrade during excavation and filling operations, including restricting the use of certain types of construction equipment and their movement over sensitive or unstable materials, dewatering and other acceptable control measures.
- 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 a minimum 12-inch layer of compacted crushed stone wrapped all around in non-woven filter fabric. Costs of removal and replacement shall be borne by the Contractor.
- C. The Contractor shall place a minimum of 12-inch layer of special bedding materials over the natural underlying soil to stabilize areas which may become disturbed as a result of rain, surface water runoff or groundwater seepage pressures, all at no additional cost to the Owner. The Contractor also has the option of drying materials in-place and compacting to specified densities.

3.2 EXCAVATION:

A. GENERAL:

1. The Contractor shall perform all work of any nature and description required to accomplish the work as shown on the Drawings and as specified.
2. Excavations, unless otherwise required by the Engineer, shall be carried only to the depths and limits shown on the Drawings. If unauthorized excavation is carried out below required subgrade and/or beyond minimum lateral limits shown on Drawings, it shall be backfilled with gravel borrow and compacted at the Contractor's expense as specified below, except as otherwise indicated. Excavations shall be kept in dry and good conditions at all times, and all voids shall be filled to the satisfaction of the Engineer.
3. In all excavation areas, the Contractor shall strip the surficial topsoil layer and underlying subsoil layer separate from underlying soils.
4. In paved areas, the Contractor shall first cut pavement as specified in paragraph 3.02 B.1 of this specification, strip pavement and pavement subbase separately from underlying soils. All excavated materials shall be stockpiled separately from each other within the limits of work.
5. The Contractor shall remove loam and topsoil, loose vegetation, stumps, large roots, etc., from areas upon which structures will be constructed or areas where material will be placed for grading. The subgrade shall be shaped as indicated on the Drawings and shall be prepared by forking, furrowing, or plowing so that the first layer of the fill material placed on the subgrade will be well bonded to the subgrade.
6. The Contractor shall follow a construction procedure, which permits visual identification of stable natural ground. Where groundwater is encountered, the size of the open excavation shall be limited to that which can be handled by the Contractor's chosen method of dewatering, and which will allow visual observation of the bottom and backfill in the dry.
7. The Contractor shall excavate unsuitable materials to stable natural ground where encountered at proposed excavation subgrade, as required by the Engineer. Unsuitable material includes topsoil, loam, peat, other organic materials, snow, ice, and trash. Unless specified elsewhere or otherwise required by the Engineer, areas where unsuitable materials have been excavated to stable ground shall be backfilled with compacted special bedding materials or crushed stone wrapped all around in non-woven filter fabric.

B. TRENCHES:

1. Prior to excavation, trenches in pavement shall have the traveled way surface cut in a straight line by a concrete saw or equivalent method, to the full depth of pavement. Excavation shall only be between these cuts. Excavation support shall be provided as required to avoid undermining of pavement. Cutting operations shall not be done by ripping equipment.
2. The Contractor shall satisfy all dewatering requirements specified in Section 31 23 19 DEWATERING, before performing trench excavations.
3. Trenches shall be excavated to such depths as will permit the pipe to be laid at the elevations, slopes, and depths of cover indicated on the Drawings. Trench widths shall be as shown on the Drawings or as specified.

4. Where pipe is to be laid in bedding material, the trench may be excavated by machinery to, or just below, the designated subgrade provided that the material remaining in the bottom of the trench is not disturbed.
5. If pipe is to be laid in embankments or other recently filled areas, the fill material shall first be placed to a height of at least 12-inches above the top of the pipe before excavation.
6. Pipe trenches shall be made as narrow as practicable and shall not be widened by scraping or loosening materials from the sides. Every effort shall be made to keep the sides of the trenches firm and undisturbed until backfilling has been completed.
7. If, in the opinion of the Engineer, the subgrade, during trench excavation, has been disturbed as a result of rain, surface water runoff or groundwater seepage pressures, the Contractor shall remove such disturbed subgrade to a minimum of 12 inches and replace with crushed stone wrapped in filter fabric. The cost of removal and replacement shall be borne by the Contractor.
8. The Contractor shall obtain a trench permit from the municipality where the trench is located prior to making any excavations of trenches (any subsurface excavation greater than three (3) feet in depth and fifteen (15) feet or less between soil walls as measured from the bottom).
9. All trenches required to be permitted must be attended, covered, barricaded, or backfilled. Covers must be road plates at least $\frac{3}{4}$ -inch thick or equivalent, barricades must be fences at least 6-feet high with no openings greater than 4-inches between vertical supports and all horizontal supports required to be located on the trench-side of the fencing.

C. BUILDING AND FOUNDATION EXCAVATION:

1. Excavations shall not be wider than required to set, brace, and remove forms for concrete, or perform other necessary work.
2. After the excavation has been made, and before forms are set for footings, mats, slabs, or other structures, and before reinforcing is placed, all loose or disturbed material shall be removed from the subgrade. The bearing surface shall then be compacted to meet the requirements of this specification.
3. If, in the opinion of the Engineer, the existing material at subgrade elevation is unsuitable for structural support, the Contractor shall excavate and dispose of the unsuitable material to the required width and depth as required by the Engineer. If, in the opinion of the Engineer, filter fabric is required; the Contractor shall place filter fabric, approved by the Engineer, as per manufacturer's recommendations. Crushed stone shall then be placed in lifts and compacted to required densities. Backfill shall be placed to the bottom of the proposed excavation.

D. EXCAVATION NEAR EXISTING STRUCTURES:

1. Attention is directed to the fact that there are pipes, manholes, drains, and other utilities in certain locations. An attempt has been made to locate all utilities on the drawings, but the completeness or accuracy of the given information is not guaranteed.
2. As the excavation approaches pipes, conduits, or other underground structures, digging by machinery shall be discontinued and excavation shall be done by

means of hand tools, as required. Such manual excavation, when incidental to normal excavation, shall be included in the work to be done under items involving normal excavation.

3. Where determination of the exact location of a pipe or other underground structure is necessary for properly performing the work, the Contractor shall excavate test pits to determine the locations.

3.3 BACKFILL PLACEMENT AND COMPACTION

A. GENERAL:

1. Prior to backfilling, the Contractor shall compact the exposed subgrade to a firm and unyielding condition with at least 4 passes of fully loaded, ten cubic yard dump truck over the subgrade or other acceptable compaction equipment subject to the approval of the Engineer. Compaction shall be observed by the Engineer.
2. After approval of subgrade by the Engineer, the Contractor shall backfill areas to required contours and elevations with specified materials.
3. The Contractor shall place and compact materials to the specified density in continuous horizontal layers, not to exceed nine (9) inches in uncompacted lifts. The degree of compaction shall be based on maximum dry density as determined by ASTM Test D1557. The minimum degree of compaction for fill placed shall be as follows:

<u>Location</u>	<u>Percent of Maximum Density</u>
Below pipe centerline	95
Above pipe centerline	92
Below pavement (upper 3 ft.)	95
Embankments	95
Below pipe in embankments	95
Adjacent to structures	92
Below structures	95

4. The Engineer reserves the right to test backfill for conformance to the specifications and the Contractor shall assist as required to obtain the information. Compaction testing will be performed by the Engineer or by an inspection laboratory designated by the Engineer, engaged and paid for by the Owner. If test results indicate work does not conform to specification requirements, the Contractor shall remove or correct the defective Work by recompacting where appropriate or replacing as necessary and approved by the Engineer, to bring the work into compliance, at no additional cost to the Owner. All backfilled materials under structures and buildings shall be field tested for compliance with the requirements of this specification.
5. Where horizontal layers meet a rising slope, the Contractor shall key each layer by benching into the slope.
6. If the material removed from the excavation is suitable for backfill with the exception that it contains stones larger than permitted, the Contractor has the option to remove the oversized stones and use the material for backfill or to provide replacement backfill at no additional cost to the Owner.

B. TRENCHES

1. Bedding as detailed and specified shall be furnished and installed beneath the pipeline prior to placement of the pipeline. A minimum bedding thickness shall be maintained between the pipe and undisturbed material, as shown on the Drawings.
2. As soon as practicable after the pipes have been laid, backfilling shall be started.
3. Unless otherwise indicated on the Drawings, select backfill shall be placed by hand shovel in 6-inch thick lifts up to a minimum level of 12-inches above the top of pipe. This area of backfill is considered the zone around the pipe and shall be thoroughly compacted before the remainder of the trench is backfilled. Compaction of each lift in the zone around the pipe shall be done by use of power-driven tampers weighing at least 20 pounds or by vibratory compactors. Care shall be taken that material close to the bank, as well as in all other portions of the trench, is thoroughly compacted to densities required.
4. Class B backfill shall be placed from the top of the select backfill to the specified material at grade (loam, pavement subbase, etc.). Fill compaction shall meet the density requirements of this specification.
5. If the materials above the trench bottom are unsuitable for backfill, the Contractor shall furnish and place backfill materials meeting the requirements for trench backfill, as shown on the drawings or specified herein.
6. Should the Engineer order crushed stone for utility support or for other purposes, the Contractor shall furnish and install the crushed stone as directed.
7. In shoulders of streets and road, the top 12-inch layer of trench backfill shall consist of processed gravel for sub-base, satisfying the requirements listed in MassDOT standard specification M1.03.1.

C. BACKFILLING UNDER BUILDINGS AND FOUNDATIONS

1. Backfill under structures shall be Structural Fill, as shown on the Drawings or as required by the Engineer. The Structural Fill shall be placed in a manner accepted by the Engineer. Compaction of each lift shall meet the density requirements of this specification.

D. BACKFILLING ADJACENT TO STRUCTURES

1. The Contractor shall not place backfill against or on structures until they have attained sufficient strength to support the loads to which they will be subjected. Excavated material approved by the Engineer may be used in backfilling around structures. Backfill material shall be thoroughly compacted to meet the requirements of this specification.
2. Contractor shall use extra care when compacting adjacent to pipes and drainage structures. Backfill and compaction shall proceed along sides of drainage structures so that the difference in top of fill level on any side of the structure shall not exceed two feet (2') at any stage of construction.
3. Where backfill is to be placed on only one side of a structural wall, only hand-operated roller or plate compactors shall be used within a lateral distance of five feet (5') of the wall for walls less than fifteen feet (15') high and within ten feet (10') of the wall for walls more than fifteen feet (15') high.

3.4 DISPOSAL OF SURPLUS MATERIALS

- A. Surplus excavated materials, which are acceptable to the Engineer, shall be used to replace other materials unacceptable for use as backfill. Upon written approval of the Engineer, surplus excavated materials shall be neatly deposited and graded so as to make or widen fills, flatten side slopes, or fill depressions; or shall be neatly deposited for other purposes as indicated by the Owner, within its jurisdictional limits; all at no additional cost to the Owner.
- B. Surplus excavated material not needed as specified above shall be hauled away and disposed of by the Contractor at no additional cost to the Owner, at appropriate locations, and in accordance with arrangements made by it. Disposal of all rubble shall be in accordance with all applicable local, state and federal regulations.
- C. No excavated material shall be removed from the site of the work or disposed of by the Contractor unless approved by the Engineer. Coordinate the disposal of excess excavated materials with Section 02 61 00.13 HANDLING AND DISPOSAL OF EXCAVATED SOIL AND DEWATERING EFFLUENT.
- D. The Contractor shall comply with Massachusetts regulations (310 CMR 40.0032) that govern the removal and disposal of surplus excavated materials. Materials, including contaminated soils, having concentrations of oil or hazardous materials less than an otherwise Reportable Concentration and that are not a hazardous waste, may not be disposed of at locations where concentrations of oil and/or hazardous material at the receiving site are significantly lower than the levels of those oil and /or hazardous materials present in the soil being disposed or reused.

END OF SECTION

SECTION 31 05 19.13

GEOTEXTILE FABRICS

PART 1 – GENERAL

1.1 WORK INCLUDED

This Section covers furnishing of all labor, materials, and equipment necessary to install specified geotextile fabrics in locations shown on the drawings and as required by the Engineer.

1.2 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 00 SUBMITTAL PROCEDURES, SUBMIT THE FOLLOWING:

Shop drawings or working drawings and material specifications shall be submitted to the Engineer for review for each type of geotextile fabric furnished. General installation practices and installation schedule shall be included.

PART 2 – PRODUCTS

2.1 FILTER/DRAINAGE FABRIC:

- A. The filter/drainage fabric shall be composed of continuous-filament fibers bonded together to form a sheet. The fabric shall be an average of 20 mils thick and possess the characteristics of Mirafi 140N.
- B. The filter/drainage fabric shall be Mirafi 140N as manufactured by Solmax; Foss-65 by AJ Nonwovens; US 120NW, as manufactured by US Fabrics or approved equal.

2.2 GEOTEXTILE LINER PROTECTOR:

- A. The geotextile liner protector shall be a non-woven, needle-punched polyester or extruded polypropylene, not less than 110 mils thick.
- B. The geotextile liner protector shall be Mirafi 180 N, by Solmax or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. GENERAL:

Installation of geotextile fabrics shall be strictly in accordance with manufacturers' instructions and specific layout plans and details reviewed by the Engineer.

B. FILTER/DRAINAGE FABRIC:

- 1. The filter/drainage fabric shall be installed in the final graded trench bottom prior to placement of the crushed stone bedding and at other locations shown on the drawings or designated by the Engineer. The drainage fabric in place shall cover the entire trench bottom and trench sides as shown on the drawings. Each

width of drainage fabric shall be overlapped in accordance with manufacturer's recommendations, but not less than 2 feet, to prevent intrusion of soil fines into the bedding.

2. On landfill projects, the filter/drainage fabric shall be installed over the drainage layer prior to loaming and seeding, per manufacturer's installation recommendations.

C. GEOTEXTILE LINER PROTECTOR:

The geotextile liner protector shall be installed on top of the gas-venting layer and shall be covered by the flexible membrane liner. The protector shall provide a smooth surface to support the liner and protect against liner damage due to projections. The installation shall be strictly in accordance with manufacturer's recommendations.

3.2 FINAL INSPECTION AND ACCEPTANCE:

- A. The Contractor shall, at its expense, have a manufacturer's representative inspect the work at completion of the installation. Any work found to be unsatisfactory shall be corrected at the Contractor's expense.
- B. The Engineer, at the Contractor's expense, reserves the right to have a manufacturer's representative inspect the installation process at any time during construction.

END OF SECTION

SECTION 31 23 19

DEWATERING

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This section specifies designing, furnishing, installing, maintaining, operating and removing temporary dewatering systems as required to lower and control water levels and hydrostatic pressures during construction; disposing of pumped water; constructing, maintaining, observing and, except where indicated or required to remain in place, removing of equipment and instrumentation for control of the system.

1.2 RELATED WORK

- A. Section 00 31 00 AVAILABLE PROJECT INFORMATION
- B. Section 00 31 43, PERMITS
- B. Section 31 00 00, EARTHWORK
- C. Section 31 25 00, EROSION AND SEDIMENTATION CONTROL
- D. Section 31 50 00, SUPPORT OF EXCAVATION

1.3 SYSTEM DESCRIPTION

- A. Dewatering includes lowering the water table and intercepting seepage which would otherwise emerge from the slopes or bottom of the excavation; increasing the stability of excavated slopes; preventing loss of material from beneath the slopes or bottom of the excavation; reducing lateral loads on sheeting and bracing; improving the excavation and hauling characteristics of sandy soil; preventing rupture or heaving of the bottom of any excavation; and disposing of pumped water.

1.4 QUALITY ASSURANCE

- A. The Contractor is responsible for the adequacy of the dewatering systems.
- B. The dewatering systems shall be capable of effectively reducing the hydrostatic pressure and lowering the groundwater levels to a minimum of 2 feet below excavation bottom, unless otherwise required by the Engineer, so that all excavation bottoms are firm and dry.
- C. The dewatering system shall be capable of maintaining a dry and stable subgrade until the structures, pipes and appurtenances to be built therein have been completed to the extent that they will not be floated or otherwise damaged.
- D. The dewatering system and excavation support (see Section 31 50 00, SUPPORT OF EXCAVATION) shall be designed so that lowering of the groundwater level outside the excavation does not adversely affect adjacent structures, utilities or wells.

1.5 SUBMITTALS

- A. In accordance with Section 01 33 00, Contractor shall submit a plan indicating how it intends to control the discharge from any dewatering operations on the project, whether it is discharge of groundwater from excavations or stormwater runoff during the life of the project.

PART 2 - PRODUCTS: NOT APPLICABLE

PART 3 - EXECUTION

3.1 DEWATERING OPERATIONS

- A. All water pumped or drained from the work shall be disposed of in a manner that will not result in undue interference with other work or damage to adjacent properties, pavements and other surfaces, buildings, structures and utilities. Suitable temporary pipes, flumes or channels shall be provided for water that may flow along or across the site of the work. All disposal of pumped water shall conform to the provisions of Section 00 31 43 PERMITS and Section 31 25 00 EROSION AND SEDIMENTATION CONTROL.
- B. Dewatering facilities shall be located where they will not interfere with utilities and construction work to be done by others.
- C. Dewatering procedures to be used shall be as described below:
 - 1. Crushed stone shall encapsulate the suction end of the pump to aid in minimizing the amount of silt discharged.
 - 2. For dewatering operations with relatively minor flows, pump discharges shall be directed into straw bale sedimentation traps lined with filter fabric. Water is to be filtered through the straw bales and filter fabric prior to being allowed to seep out into its natural watercourse.
 - 3. For dewatering operations with larger flows, pump discharges shall be into a steel dewatering basin. Steel baffle plates shall be used to slow water velocities to increase the contact time and allow adequate settlement of sediment prior to discharge into waterways.
 - 4. Where indicated on the contract drawings or in conditions of excess silt suspended in the discharge water, silt control bags shall be utilized in catch basins.
- D. The Contractor shall be responsible for repair of any damage caused by its dewatering operations, at no cost to the Owner.

END OF SECTION

SECTION 31 25 00

EROSION AND SEDIMENTATION CONTROL

PART 1 - GENERAL

1.1 SCOPE OF WORK

Furnish all labor, materials, tools and equipment, and perform all operations necessary for erosion and sedimentation control work indicated on contract drawings and as specified herein.

1.2 RELATED WORK

- A. Section 01 14 19.16, DUST CONTROL
- B. Section 31 05 19.13, GEOTEXTILE FABRICS

1.3 PROJECT CONDITIONS:

- A. Earthmoving activities in the project area shall be conducted in such a manner as to prevent accelerated erosion and the resulting sedimentation.
- B. The Contractor shall implement and maintain erosion and sedimentation control measures as shown on the contract drawings or as required by the Owner or Engineer from the start of construction until provisional acceptance of seeded areas, to effectively prevent accelerated erosion and sedimentation.

1.4 SUBMITTALS IN ACCORDANCE WITH SECTION 01 33 00, SUBMITTAL PROCEDURES: The Contractor shall submit to the Engineer certification that the materials used for silt fence and straw wattle construction meet the specifications.

1.5 GENERAL METHODOLOGY:

- A. Erosion and sedimentation control methods shall consider all factors which contribute to erosion and sedimentation including, but not limited to, the following:
 - 1. Topographic features of the Project area.
 - 2. Types, depth, slope and areal extent of the soils.
 - 3. Proposed alteration of the area.
 - 4. Amount of run-off from the Project area and the upgradient watershed areas.
 - 5. Staging of earthmoving activities.
 - 6. Temporary control measures and facilities for use during earthmoving.

PART 2 - PRODUCTS

2.1 MATERIALS:

- A. Straw wattle shall consist of 99.9% weed-free wheat, oat, barley, or rice straw, compacted. Diameter may vary +/- 13 percent. Wattle netting shall be non-woven photodegradable HDPE with a 1-year UV inhibitor.

- B. Silt Fence shall be a woven polypropylene and/or polyester material, which meets or exceeds the minimum average roll values requirements tabulated below:

Fabric Property	Test Method	Fabric Requirement
Tensile strength, lbs.	ASTM D-4632 Grab	100 minimum
Elongation at 50% minimum tensile strength	ASTM D-4632 Grab	15%
Permittivity, sec ⁻¹	ASTM D-4491	0.1 minimum
Apparent opening size, mm	ASTM D-4751	30 US Sieve
Ultraviolet degradation at 500 hours	ASTM D-4355	minimum 70% strength retained

- C. Mulch, if used to protect the hydroseed from erosion, shall consist of cured straw free from primary noxious weed seeds, twigs, debris and rough or woody materials. Mulch shall be free from rot or mold and shall be acceptable to the Engineer or Owner. Alternately, mulch shall be specially processed cellulose homogeneous fiber containing no growth or germination-inhibiting factors. Processed cellulose fiber shall be manufactured in such a manner that after addition and agitation in slurry tanks with water, the fibers in the material become uniformly suspended to form a slurry when sprayed on the ground. The material shall allow homogeneous absorption and percolation of moisture. The manufacturer shall show the air-dry weight content on each package of the cellulose fiber. Mulch shall be utilized on all newly graded subgrade and topsoil areas that cannot be seeded within five (5) days.

PART 3 - EXECUTION

3.1 CONSTRUCTION SEQUENCE:

- A. Construction of erosion control measures as depicted on drawings will be completed prior to any site work.
- B. Sediment barriers shall be used at locations shown on the drawings. Sediment barriers are temporary berms, diversions, or other barriers that are constructed to retain sediment on-site by retarding and filtering stormwater runoff.
- C. All temporary erosion control measures will be maintained throughout the course of site construction activities until provisional acceptance of the site vegetation by the Engineer or Owner, at which time the Contractor shall remove all remaining temporary erosion control structures, and properly dispose of accumulated sediment on-site in areas approved by the Owner.
- D. The Engineer or Owner may order additional erosion and sediment controls be installed. The Contractor shall comply with Engineer or Owner's request and immediately install the required controls.

- E. The Contractor shall inspect all erosion control measures after any storm event to ensure they are in proper working order.

3.2 CONSTRUCTION METHODS:

- A. Silt fences and/or straw wattles shall be installed at the site downgradient of work areas as required by Owner or Engineer in the field. The silt fence shall be installed in accordance with manufacturer's instructions. Straw wattles shall be placed at locations shown on the contract drawings or approved by the Engineer. The base of all straw wattles and silt fencing shall be embedded to the depths shown on the contract drawings.
- B. Straw mulch, if used, shall be applied at a rate of 100-lbs/1000 ft².
- C. On slopes, the Contractor shall provide protection against washouts by an approved method. Any washout, which occurs either in the Contractor's work area or in areas topographically below its work, shall be regraded and reseeded at the Contractor's expense until an accepted vegetative stand is established.

END OF SECTION

SECTION 31 50 00

SUPPORT OF EXCAVATION

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This section covers wood and steel sheeting or soldier piles and lagging with internal bracing for support of excavations. The requirements of this section shall also apply, as appropriate, to any methods of excavation support and underpinning which the Contractor elects to use to complete the work.
- B. The Contractor shall design, furnish, and place support of excavation systems of the kinds and dimensions required, complying with these specifications, where required by regulation, indicated on the drawings or required by the Engineer.
- C. Routine monitoring of the in-place excavation support system shall be provided.

1.2 RELATED WORK

- A. Section 00 31 00, AVAILABLE PROJECT INFORMATION
- B. Section 31 00 00, EARTHWORK
- C. Section 31 23 19, DEWATERING
- D. Section 32 32 13, CAST-IN-PLACE CONCRETE RETAINING WALL

1.3 QUALITY ASSURANCE

- 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, and to the Massachusetts Department of Safety and Department of Labor, Division of Occupational Safety "Excavation & Trench Safety Regulation (520 CMR 14.00)" and "Rules and Regulations for the Prevention of Accidents in Construction Operations (454 CMR 10.0 et seq.)." Contractors shall be familiar with the requirements of these regulations.
- B. The Contractor is responsible for the adequacy of the excavation support system and shall retain the services of a Professional Engineer registered in the state where the project is located to design the 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 its design. Criteria listed herein defining the responsibilities of the Contractor's Professional Engineer are minimum requirements

1.4 REFERENCES

The following standards form a part of this specification as referenced herein.

ASTM International (ASTM)

ASTMA6 Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

ASTMA328 Standard Specification for Steel Sheet Piling

1.5 SUBMITTALS

- A. At least three weeks before starting installation of the excavation support system, the Contractor shall submit the attached Certificate of Design completed and signed by the Contractor and the Professional Engineer, identifying the Contractor's Professional Engineer who will be responsible for design of the excavation support system, and in accordance with Section 01 33 00, including, for record purposes only:
1. An overall time schedule for construction of the braced excavation system.
 2. A description of the anticipated sequence of construction.
 3. Complete details of braced excavation methods, equipment and sizes and lengths of materials proposed to be used.
 4. Details of the means and methods that will be used in monitoring the integrity of the support system during its entire period of use to ensure the safety of the excavation.
 5. Complete computations for the design of the support of excavation system bearing the seal of the responsible Professional Engineer duly registered licensed to practice within a discipline applicable to excavation work, in the state where the project is located.
 6. Any other pertinent data required for record purposes by the Engineer.
- B. Receipt of the information by the Engineer will not relieve the Contractor of the sole responsibility for the adequacy of the braced excavation system, and for assuring that there will be no resulting damage to adjacent pavement, utilities or structures, and for providing safe conditions within the sheeted areas.
- C. Further for the record, upon completion of the work of this section, the Contractor shall submit all records of survey, vibration monitoring and inspection of existing structures to the Owner's Engineer.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Timber sheeting shall be sound spruce, pine, or hemlock, and either tongue and grooved or splined. Timber sheeting shall not be less than nominal 2-inches thick.
- B. Where steel sheet piling is indicated on the drawings or installation is ordered by the Engineer or required by OSHA standards, the material shall be of such size and strength as required by the excavation support design prepared and submitted by the Contractor's Professional Engineer. Steel sheet piling may be new or used material but shall not contain splices, cutouts, patches, or other alterations which would impair its integrity or strength. Steel sheeting shall be an approved standard section, weighing not less than 22 pounds per square foot of wall and conforming to ASTM A6 and A328.
- C. Where soldier piles and lagging are used, the steel piles shall conform to ASTM A6, and the lagging shall meet the requirements for timber sheeting, as defined above.
- D. Timber and steel used for bracing shall be of such size and strength as required in the excavation support design prepared and submitted by the Contractor's Professional Engineer. Timber or steel used for bracing shall be new or undamaged used material, which does not contain splices, cutouts, patches, or other alterations, which would impair its integrity or strength.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Work shall not be started until all materials and equipment necessary for construction are either on the site of the work or satisfactorily available for immediate use as required.
- B. The support of excavation system shall be sufficiently tight to minimize any resulting lowering of the groundwater level outside the excavation, as required in Section 31 23 19, DEWATERING.
- C. The sheeting/piling shall be driven by approved means to the design elevation. No ends or edges of sheeting/piling shall be left exposed in a manner, which could create a possible hazard to the safety of the public or a hindrance to traffic of any kind.
- D. If boulders or very dense soils are encountered, making it impractical to drive a sheeting/piling section to the desired depth, the section shall be treated as directed by the Contractor's Engineer.
- E. Within seven days of completing the initial installation of the earth support system, the Contractor shall submit a certification from its Professional Engineer, stating that the excavation support system as installed is in general compliance with the design or approved modifications thereto.

- F. The sheeting/piling shall be left in place where indicated on the drawings or required by the Engineer in writing. At all other locations, the sheeting/piling may be left in place or salvaged at the option of the Contractor. Wood or steel sheeting/piling permanently left in place shall be cut off at a depth of not less than two feet below finish grade unless otherwise required.
- G. All cut-off material is the property of the Contractor and shall be promptly removed by it from the site.
- H. The satisfactory construction and maintenance of the excavation support system, complete in place, shall be the responsibility of the Contractor.
- I. The Contractor shall be responsible for promptly repairing all damage to adjacent structures caused by the installation, performance, or removal of the excavation support system.

END OF SECTION

(Certificate of Design follows this page)

CERTIFICATE OF DESIGN

RE: Contract between
OWNER: _____
and (Name)
CONTRACTOR: _____
on (Name)
CONTRACT: _____
(Title)

(Number) (Date)

The undersigned hereby certify that the engineer listed below:

1. Is licensed or registered to perform professional engineering work in the state of _____;
(Location of Project)
2. Is qualified by education and training to design the _____
specified in Section _____ of subject contract;
3. Has previously designed comparable excavation support systems;
4. Has prepared the design in full compliance with the requirements of subject contract, including all applicable laws, regulations, rules, and codes; and
5. Will inspect and supervise installation of the excavation support system and will monitor the in-place system to confirm that the system is installed and functions in accordance with the design.

CONTRACTOR

ENGINEER

By: _____
(Signature)

By: _____
(Signature)

(Name)

(Name)

(Title)

(Engineering Discipline)

(Date)

(Date)

SECTION 32 11 00

SIDEWALK CONSTRUCTION AND REPLACEMENT

PART 1 - GENERAL

1.1 WORK INCLUDED:

The Contractor shall furnish all labor, materials, equipment and incidentals required to construct new or replacement hot mix asphalt or cement concrete sidewalks where directed or where existing sidewalks are disturbed by the Contractor, as shown on the drawings and described herein. The Contractor shall also furnish all materials and install pedestrian curb ramps where shown on the drawings or as required by the Engineer.

1.2 RELATED WORK:

- A. Section 31 00 00, EARTHWORK
- B. Section 32 16 00, CURBING

1.3 REFERENCES:

The following standards form a part of these specifications, as referenced:

Massachusetts Department of Transportation (MassDOT)
Standard Specifications for Highways and Bridges

Section 701 Cement Concrete Sidewalks, Pedestrian Curb Ramps and Driveways

Section 702 Hot Mix Asphalt Sidewalks and Driveways
Code of Massachusetts Regulations (CMR)

521R 24 Ramps

1.4 SUBMITTALS:

- A. In accordance with Section 01 33 00 SUBMITTAL PROCEDURES, the Contractor shall submit shop drawings and/or materials specifications for each component of the work to be performed under this section of the Specifications.

1.5 SYSTEM DESCRIPTION:

- A. HOT MIX ASPHALT AND CEMENT CONCRETE SIDEWALKS AND PEDESTRIAN CURB RAMPS:
 - 1. Except as otherwise indicated, hot mix asphalt and cement concrete sidewalks and pedestrian curb ramps shall be constructed in accordance with the

requirements of Sections 701 and 702 of the latest edition of the MassDOT Standard Specifications for Highways and Bridges, and all amendments thereto.

2. Pedestrian curb ramps shall be installed in new sidewalks at intersections in accordance with 521 CMR 24 and Mass DOT Section 701. When curbs or sidewalks are constructed or reconstructed on one side of the street, curb cuts shall also be installed on the opposite sides of the street, where there is a pedestrian path of travel. Curb cuts shall be located within the crosswalk and/or the pedestrian path of travel.
- B. Water boxes, manhole frames, and all other castings shall be carefully set to the proposed finished grade.
- C. Sidewalks shall not be less than 48-inches in width, excluding curbing. An unobstructed path of travel shall be provided which is at least 36-inches clear, excluding curbing.

PART 2 - PRODUCTS

2.1 HOT MIX ASPHALT SIDEWALKS:

- A. Sidewalks shall consist of hot mix asphalt.
- B. Hot mix asphalt shall conform to the requirements of MassDOT M3.06.0.

2.02 CEMENT CONCRETE SIDEWALKS AND PEDESTRIAN CURB RAMPS:

- A. Cement concrete sidewalks shall be constructed with air entrained Cement Concrete with a minimum compressive strength of 4000 psi at 28 days.
- B. Cement concrete shall conform to the requirements of MassDOT M4.02.00.

PART 3 - EXECUTION:

3.1 HOT MIX ASPHALT SIDEWALKS:

- A. The subgrade for the sidewalks shall be shaped parallel to the proposed surface of the sidewalks and shall be thoroughly rolled and tamped. All depressions occurring shall be filled with suitable material and again rolled or tamped until the surface is smooth and hard in order for a gravel foundation to be placed upon it.
- B. The hot mix asphalt sidewalk shall be a minimum of 2½ compacted inches thick, laid in two equal courses. The sidewalk pitch shall be 3/16-inch per foot of width or shall match the existing sidewalk.

3.2. CEMENT CONCRETE SIDEWALKS AND PEDESTRIAN CURB RAMPS:

- A. Concrete for sidewalks and pedestrian curb ramps shall be a minimum of 4-inches thick. At driveways, the sidewalks shall be 6-inches thick.

- B. The subgrade for the walk or driveway shall be shaped to a true surface conforming to the proposed slope of the walk, thoroughly rolled at optimum moisture content and tamped with a power roller weighing not less than one ton and not more than 5 tons. All depressions occurring shall be filled with suitable material and again rolled or tamped until the surface is smooth and hard.
- C. After the subgrade has been prepared as hereinbefore specified, a subbase of gravel borrow at optimum moisture content shall be placed, thoroughly rolled by a power roller, and tamped. The gravel borrow shall be a minimum of 8-inches in thickness.
- D. The forms for sidewalks shall be smooth, free from warp, strong enough to resist springing out of shape, and deep enough to conform to the thickness of the proposed walk. All mortar or dirt shall be completely removed from forms that have been previously used. The forms shall be well staked, thoroughly braced, and set to the established lines with their upper edge conforming to the grade of the finished walk. The finished walk shall have sufficient pitch from the outside to the edge of the walk to provide for surface drainage. This pitch shall be ¼-inch per foot unless otherwise directed by the Engineer. Before the concrete is placed, the subbase for sidewalks shall be thoroughly dampened until it is moist throughout but without puddles of water.
- E. Concrete shall be conveyed from the place of mixing to the place of deposit in such a manner that no mortar will be lost, and the composition of the mix shall be uniform, showing neither excess nor lack of mortar in any one place. The consistency shall be such that water will float to the surface under heavy tamping. The concrete shall be placed as close to its final position as practicable and thoroughly consolidated, with precautions taken not to overwork it while it is still plastic. The concrete shall be thoroughly spaded along the forms or screeds to eliminate voids and honeycombs at the edges. Retempering of concrete will not be permitted.
- F. Concrete shall be placed in alternate slabs not exceeding 30 feet in length. Slabs shall be separated by transverse preformed expansion joint filler ½-inch thick. The surface of all concrete sidewalks shall be uniformly scored into block units of not more than 40 square feet. The depth of the scoring shall be at least one quarter of the thickness of the sidewalk.
- G. When concrete sidewalks are constructed adjacent to curbing, building foundations, retaining walls, light pole bases or fixed structures, ½-inch thick premolded joint filler shall be used between the newly constructed sidewalk and the structure.
- H. Finishing of the concrete surface shall be done by experienced and competent cement finishers as soon as is practicable. Finishing shall be delayed until all bleed water and water sheen has left the surface and the concrete has begun to stiffen. The concrete surface shall be finished as directed with a steel trowel or wood float to give a smooth, uniform and attractive surface finish and uniformly scored into block units or areas of not more than 36 square feet. Following this, the Contractor shall draw a nylon push broom lightly over the surface to produce a non-slip surface. Application of neat cement to the surface to hasten hardening is prohibited.

- I. The Contractor shall protect the newly placed concrete surface against vandalism and marking or defacing and must stand ready to replace any blocks which, in the opinion of the Engineer, are excessively marked or defaced, at no additional cost to the Owner. When completed the walks shall be kept moist and protected from traffic and weather for at least 3 days.
- J. Adequate protection shall be provided where temperatures of 40°F or lower occur during placing of concrete and during the early curing period. The minimum temperature of fresh concrete after placing and for the first 3 days shall be maintained above 55°F. In addition to the above requirements, an additional 3 days of protection from freezing shall be maintained.

END OF SECTION

SECTION 32 12 16
HOT MIX ASPHALT PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the documents identified in Division 00 Bidding and Contract Requirements and Division 01 General Requirements.

1.2 SUMMARY

- A. This Section includes the following:
1. Inspection and acceptance of earthwork operations and base course installed under Division 31.
 2. Asphalt paving, including patching and overlays.
 3. Pavement-markings.
- B. Related Sections include the following:
1. Section 31 00 00 EARTHWORK
 2. Section 32 16 00 CURBING
 3. Section 33 39 13 PRECAST MANHOLES AND CATCH BASINS

1.3 DEFINITIONS

- A. SSHB: "Commonwealth of Massachusetts Department of Transportation Standard Specifications for Highways and Bridges", Commonwealth of Massachusetts, Massachusetts Highway Department, 2024 edition, including all Divisions and Supplements.

1.4 REFERENCES:

The following standards form a part of these specifications and indicate the minimum standards required:

ASTM International (ASTM)

ASTM D1557	Test for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10 Pound Rammer and 18-Inch Drop

HOT MIX ASPHALT PAVING
32 12 16 - 1

Massachusetts Department of Transportation (MassDOT)
Standard Specifications for Highways and Bridges

MassDOT	401	Gravel Sub-base Course
MassDOT	402	Dense Graded Crushed Stone for Sub-base
MassDOT	403	Reclaimed Base Course
MassDOT	405	Gravel Base Course
MassDOT	420	Hot Mix Asphalt Base Course
MassDOT	460	Hot Mix Asphalt Pavement
MassDOT	476	Cement Concrete Pavement
MassDOT	860	Reflectorized Pavement Markings
MassDOT	M3	Bituminous Materials

Federal Specifications

SS-S-1401	Sealants, Joint, Non-Jet-Fuel-Resistant, Hot Applied, for Portland Cement and Asphalt Concrete Pavement

AASHTO Standard Specifications for Materials and Methods of Sampling and Testing

1.5 SUBMITTALS

- A. Product Data for each product specified. Include technical data and tested physical and performance properties.
- B. Complete Job Mix Formula for each job mix proposed for the Work shall be submitted to the Engineer at least two weeks before any of the work of this section is to begin.
- C. Shop Drawings: Indicate pavement markings, lane separations, and defined parking spaces. Indicate dedicated handicapped spaces with international graphics symbol.
- D. Samples: 12 by 12 inches minimum, of paving fabric.
- E. Qualification data: For firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owner, and other information specified.
- F. Material Certificates: Certificates signed by manufacturers certifying that each material complies with requirements.
- G. As-built survey of pavements to be included with final As-built. Refer to Paragraph "Field Quality Control", below and Section 01 "Execution".

1.6 QUALITY ASSURANCE

- A. **Installer Qualifications:** Engage an experienced installer who has completed asphalt paving for a minimum of five running tracks in the last two years, for a minimum of three years for general paving similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.
- B. **Manufacturer Qualifications:** Engage a firm experienced in manufacturing asphalt paving similar to that indicated for this Project and with a record of successful in-service performance.
 - 1. Firm shall be a registered and approved paving mix manufacturer with authorities having jurisdiction or with the DOT of the state in which Project is located.
- C. **Regulatory Requirements:** Modify pavement details and provide additional thicknesses as required to conform to applicable standards for State and local authorities having jurisdiction for work on public property. Secure all permits that are required.
- D. **Walks, parking spaces and loading zones constructed for use by persons with accessibility challenges shall conform to the applicable portions of the Americans With Disability Act Accessibility Guidelines (ADA) and the Massachusetts State Building Code.**
- E. **Detectable warning surfaces must be installed at the bottom of all curb ramps, in accordance with the Americans with Disabilities Act Accessibility Guidelines. The bottom 24 inches of any curb ramp shall contain a truncated-dome tactile surface, of contrasting color to the walk surface, 6 inches back from the curb line, for the full width of the ramp surface.**
- F. **Asphalt-Paving Publications Requirements:** Comply with AI's "The Asphalt Handbook", and ASTM and AASHTO requirements except where more stringent requirements are indicated herein.
- G. **Pre-installation Conference:** Conduct conference at Project site to comply with requirements of Division 1, Section "Project Coordination" Review methods and procedures related to asphalt paving including, but not limited to the following:
 - 1. Review proposed sources of paving materials, including capabilities and location of manufacturing plant.
 - 2. Review condition of substrate and preparatory work performed by other trades.
 - 3. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.
 - 4. Review and finalize construction schedule for paving and related work. Verify availability for materials, paving Installer's personnel, and equipment required to execute the Work without delays.
 - 5. Review inspection and testing requirements, governing regulations, and proposed installation procedures.
 - 6. Review forecasted weather conditions and procedures for coping with unfavorable conditions.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pavement-marking materials to Project site in original packages with seal unbroken and bearing manufacturers' 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 and within temperature range required by manufacturer. Protect stored materials from direct sunlight.

PART 2 - PRODUCTS

2.1 GRAVEL SUBBASE

- A. Gravel subbase shall consist of inert material that is hard durable stone and coarse sand, free from loam and clay, surface coatings and delirious materials.
- B. Gradation requirements for gravel subbase shall be as specified in Section 31 00 00, EARTHWORK.

2.2 ASPHALT MATERIALS

- A. Pavement shall consist of hot mix asphalt.
- B. Binder Course: Pavement mixtures shall be within the composition limits of, binder course, in accordance with MassDOT M3.11.03, with constituents that conform to SUPERPAVE as specified in current MassDOT Standard Specifications.
- C. Surface Course: Pavement mixtures shall be within the composition limits of top course in accordance with MassDOT M3.11.03, with constituents that conform to SUPERPAVE as specified in current MassDOT Standard Specifications.
- D. The joint sealant shall be a hot poured rubberized emulsified asphalt sealant meeting the requirements of FS SS-S-1401
- E. Tack Coat: SSHB, Section M3.03.0: Emulsified asphalt (AASHTO M 140) or M3.03.1 Cationic emulsified asphalt (AASHTO M 208)}
- F. Pavement Markings:
 - 1. Pavement markings shall conform to the requirements of MassDOT 860.
 - 2. Parking lines, stop bars, Handicap Symbols and aisles: Fast Drying White Traffic Paint, per SSHB, Section M7.01.23.
 - 3. Crosswalks: retro reflective thermoplastic preformed material, 90 mils thick, consisting of a homogeneous mixture of high quality polymeric thermoplastic binders, pigments, fillers and glass beads. Materials shall conform to AASHTO, M249-79 (86) except for material being pre-formed. Color shall be white.

4. Driveway center lines (two-way traffic): Fast drying yellow traffic paint, as per SSHB, Section M7.01.24.
5. Detectable Warning Surface: Refer to Section "Unit Paving."

PART 3 - EXECUTION

3.1 GENERAL

Paving courses required for the project shall be as shown on the drawings and as specified herein. Pavement thicknesses specified are measured in compacted inches. If a pavement course thickness exceeds 2-1/2 compacted inches, the course shall be installed in multiple lifts with each lift not exceeding 2-1/2 compacted inches in thickness.

3.2 GRAVEL SUBBASE:

- A. The gravel subbase to be placed under pavement shall consist of gravel evenly spread and thoroughly compacted, with a course thickness as specified by the typical pavement section detail in the Drawings.
- B. The material shall be spread in layers not more than 4-inches thick, compacted measure. All layers shall be compacted to not less than 95 percent of the maximum dry density of the material as determined by ASTM D1557 Method C at optimum moisture content.

3.3 PROJECT CONDITIONS

- A. Environmental Limitations: Do not apply asphalt materials if substrate is wet or excessively damp or the following conditions are not met:
 1. Prime and Tack Coats: Minimum surface temperature of 60 deg F.
 2. Slurry Coat: Comply with weather limitations of ASTM D 3910.
 3. Bituminous Concrete Base Course: Minimum surface temperature of 40 deg F and rising at time of placement, or conform to State Highway Specifications.
 4. Bituminous Concrete Surface course: Minimum surface temperature of 60 deg F at time of placement, or conform to State Highway Specifications.
- B. Pavement-Markings: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 deg F for oil based materials, 50 deg F for water based materials, and not exceeding 95 deg F.
- C. Grade Control: Establish and maintain the required lines and grades, including crown, inverted crown, and cross-slopes, for each course during paving operations. Inclination control of pavements at track and field events is extremely critical. Conform to tolerances listed in this specification.

3.4 EXAMINATION

- A. Verify that base is dry and in suitable condition to support paving and imposed loads. Ensure proper drainage at all times.
- B. Proof-roll base using heavy, pneumatic-tire rollers to locate areas that are unstable or that require further compaction. Subbase surface to be smooth, free of irregularities, depressions, or unsuitable materials.
- C. Notify Architect in writing of any unsatisfactory conditions. Do not begin paving installation until these conditions have been satisfactorily corrected.
- D. Frame Adjustments:
 - 1. Verify frames for manholes, catch basins, and other such improvements, within areas to be paved, are at their proper elevation.
 - 2. Adjust frames if required. Provide temporary closures over openings until completion of rolling operations. Remove closures at completion of the work. Set covers to grade, flush with the surface of adjoining pavement surface.

3.5 TEMPORARY BITUMINOUS PAVEMENT

- A. Where specified and required by the Engineer and after placement of the gravel subbase, the Contractor shall place temporary bituminous pavement above the trench, between the edges of the existing pavement. It shall consist of hot mix asphalt, 2-inches thick, in accordance with MassDOT 460.
- B. The temporary pavement shall be repaired as necessary to maintain the surface of the pavement until replaced by permanent pavement. When so required by the Engineer, the Contractor shall remove the temporary pavement and install or regrade the subbase for installation of permanent pavement.

3.6 PATCHING AND REPAIRS

- A. Patching: Saw cut perimeter of patch and excavate existing pavement section to sound base. Re-compact new subgrade. Excavate rectangular patches, parallel and perpendicular to the direction of traffic, extending 12 inches into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Laminate courses. Feathering of edges and transitions between new and existing pavements is not acceptable.
 - 1. Apply tack coat to faces of excavation and allow to cure before paving.
 - 2. Fill excavation with dense-graded, hot mix asphalt base mix and, while still hot, compact flush with adjacent surface.
 - 3. Partially fill excavation with dense-graded, hot-mix asphalt base mix and compact while still hot. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.
- B. Crack and Joint Filling: Remove existing filler material from cracks or joints to a depth of ¼ inch. Refill with asphalt joint-filling material to restore watertight condition. Remove excess filler that has accumulated near cracks or joints. Crack and joint fill

prior to any sealcoating. All vegetation shall be removed from cracks in pavements and along curb lines by heat lance (2,800-degree equipment) prior to crack and joint filling.

- C. Tack Coat: Apply uniformly with a powered pressure system to existing surfaces of previously constructed asphalt or Portland cement concrete paving and to surfaces abutting or projecting into new, bituminous concrete pavement. Apply at a uniform rate of 0.05 to 0.15 gal./sq. yd. of surface. Excessive application of tack coat is not permissible and shall be removed.
1. Surface to receive tack coat shall be clean, free from silt, dust, soil, pavement grindings and other foreign matter and dry.
 2. Tack coat shall be a constant uniform sprayed application covering a minimum of 98% of the surface to be paved. Swirls or ribbon strips of tack coat are not acceptable. Contractor is responsible for correctly setting pressure, nozzle size and angle, spray bar height and emulsion temperature from applicator.
 3. Allow tack coat to cure (a minimum of 24 hours) undisturbed before paving. No one shall drive or walk across the surface while it is curing.
 4. Tack coat shall be applied to all asphalt surfaces whose application are five days or older or that have had excessive construction traffic that requires dust and debris removal.
 5. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.7 SURFACE PREPARATION

- A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.
1. Sweep loose granular particles from surface of unbound-aggregate base course. Do not dislodge or disturb aggregate embedded in compacted surface of base course.

3.8 BITUMINOUS PAVEMENT PLACING

- A. The bituminous paving mixture, equipment, methods mixing and placing and the precautions to be observed as to weather, condition of base, etc., shall be in accordance with MassDOT 460.
- B. Machine place bituminous pavement mix on prepared surface, spread uniformly, and strike off. The equipment for spreading and finishing shall be mechanical, self-powered pavers, capable of spreading and finishing the mixture true to line, grade, width and crown. The mixtures shall be placed and compacted only at such times as to permit proper inspection and checking by the Engineer Place bituminous pavement mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness, when compacted. Conform to SSHB, Section 460 including transport of material.
1. Spread mix at minimum temperature of 250 deg F.

2. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes, unless otherwise indicated.
 3. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.
- C. Immediately prior to installing the base and binder courses, the trimmed edges shall be made stable and unyielding, free of loose or broken pieces and all edges shall be thoroughly broomed clean. Contact surfaces of trench sides, curbing, manholes, catch basins, or other appurtenant structures in the pavement shall be painted thoroughly with a uniform coating of asphalt emulsion (tack coat), just before any mixture is placed against them.
- D. Place paving in consecutive strips not less than 10 feet wide, except where infill edge strips of a lesser width are required.
1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Complete asphalt base course and binder course for a section before placing asphalt surface course.
- E. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.
- F. Protect installed curb, walls, and other improvements, during paving operations. Repair/replace/reset any item/ curb damaged during paving operation. Joint between bituminous pavement shall be of equal density to other areas of pavement.
- G. If the asphalt surface course is not installed immediately after the binder course is installed and stabilized, the Contractor assumes all responsibility for any damage, from whatever source, which may affect the binder course. The binder course shall be repaired as necessary to maintain the surface of the pavement until placement of the permanent overlay. All damage to this binder course will be removed and replaced by the Contractor, at no additional cost to the Owner. The Architect shall be the sole judge of the limits and extents of pavement and subgrade to be replaced. If required, the Contractor shall place a leveling course before placing the permanent overlay.
- H. Top course shall be placed over the trench or full width as shown on the drawings or as specified. Prior to placement of the top course, the entire surface over which the top course is to be placed shall be broom cleaned and tack coated. Top course pavement placed over trenches may be feathered to meet existing paved surfaces, if approved by the Engineer.

3.9 JOINTS

- A. Construct joints to ensure continuous bond between adjoining paving sections. Construct joints free of depressions with same texture, density and smoothness as other sections of hot-mix asphalt course.
1. Clean contact surfaces and apply tack coat.
 2. Offset longitudinal joints in successive courses a minimum of 12 inches.
 3. Offset transverse joints in successive courses a minimum of 24 inches.

4. Construct transverse joints by bulkhead method or sawed vertical face method as described in AI's "The Asphalt Handbook".
5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
6. Compact asphalt at joints to a density within 2 percent of specified course density.

3.10 RAISING AND ADJUSTING CASTINGS:

- A. In areas of permanent top course paving, existing municipally-owned catch basin and manhole castings and valve boxes shall be raised to the proper grade where required by the Engineer.
- B. Castings owned by private utilities shall be raised by their own forces. The Contractor shall be responsible for coordinating this work.
- C. The method of adjusting these castings shall be as follows: Cut around catch basin or manhole castings a minimum of 8-inches from casting. Excavate and if required rebuild up to 12-inches of masonry below the bottom of the casting. Backfill with suitable material and compact to bottom of casting. Place high, early strength cement or bituminous concrete collar, as directed, to approximately 1½-inches below the raised casting grade. Masonry work shall conform to Section 33 39 13, PRECAST MANHOLES AND CATCH BASINS.
- D. In some areas, raising of castings may not be required. Where required by the Engineer, castings not to be raised shall have at least 12-inches of bituminous concrete pavement chipped and removed around the casting. New bituminous concrete pavement shall be placed and compacted around such castings to approximately 1-1/2-inches below the top of the casting. The overlay course shall then be sloped down to the level of the casting.
- E. The method of raising valve boxes shall be as follows: Cut around valve box a minimum of 8-inches from valve box. Excavate as required and raise the valve box. Pour high early strength cement or bituminous concrete collar, as directed, to approximately 1-1/2-inches below the top of the valve box.
- F. Castings which need to be raised or adjusted to complete permanent curb to curb paving shall be done immediately prior to paving.

3.11 COMPACTION

- A. General: After the paving mixtures have been properly spread, initial and intermediate compaction shall be obtained by the use of steel wheel rollers having a weight of not less than 240 pounds per inch width of tread. Compact hot-mix paving with hot, hand tampers or vibratory-plate compactors in area inaccessible to rollers.
 1. Complete compaction before mix temperature cools to 185 deg F.
- B. Breakdown Rolling: Accomplish breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Repair surfaces by loosening displaced material, filling with hot-mix asphalt, and re-rolling to required elevations.

- C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling, while paving mixture is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:
 - 1. Average Density: 96 percent of reference laboratory density according to AASHTO T245 but not less than 94 percent nor greater than 100 percent.
 - 2. Average Density: 92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent nor greater than 96 percent.
- D. Finish Rolling: Final rolling of the top course pavement shall be performed by a steel wheel roller weighing not less than 285 pounds per inch width of tread at a mix temperature and time sufficient to allow for final smoothing of the surface and thorough compaction.
- E. Immediately after placement of top course pavement, all joints between the existing and new top course or surface treatment pavements shall be sealed with hot poured rubberized asphalt joint sealant.
- F. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while still hot, with back of rake or smooth iron. Compact thoroughly using tamper or other satisfactory method. Raveled or untamped edges will not be accepted.
- G. Where there is no backing for the edges of the curb-to-curb pavement, the Contractor shall provide a gravel transition. The gravel transition shall be installed immediately after the pavement is placed, shall be feathered and extend a minimum of 18-inches, and shall be compacted using the same equipment as for pavement compaction. The gravel shall be uniformly graded material with a maximum size of 3/8- to 1/2-inch.
- H. Repairs: Remove paved areas that are defective or contaminated with foreign materials. Remove paving course over area affected and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.
- I. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened, and in no case sooner than 8 hours.
- J. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.12 INSTALLATION TOLERANCES

- A. Thickness: Compact each course to produce a surface smoothness within the following tolerances:
 - 1. Base Course: Plus 1/2 inch, no minus.
 - 2. Surface Course: 1/4 inch, no minus.

- B. Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:
1. Base Course: 1/4 inch.
 2. Surface Source: 1/8 inch
 3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch. In no case will water be allowed to puddle or stand on any finished pavement.
 4. Ribbons/waves in longitudinal runways will not be accepted. Replace as directed.

3.13 SEALCOATING

- A. See Patching and Repairs for surface preparation. Seal coat all areas called out on plans. Apply two coats perpendicular to each other. If any area is transparent and old striping can be discerned, reapply.

3.14 PAVEMENT MARKINGS

- A. Do not apply pavement markings until layout, colors, and placement and pavement conditions have been approved by the Architect. Conform to SSHB, Section 860 and the manufacturer's recommendations and instructions for application. Remove existing lines from remaining pavements as required and approved by Owner. Painting out lines is not acceptable.
- B. Allow paving to cure for a minimum of 14 days or per manufacturer's requirements before starting pavement marking.
- C. Thoroughly sweep and clean surface to eliminate loose material and dust.
- D. Apply paint with mechanical equipment to produce pavement markings of dimensions indicated with uniform, straight edges. Avoid fogging and overspray. Note specific dimensions and layout requirements for markings:
1. Parking Spaces – 4" wide.
 2. Handicap Seating – 2" wide.
 3. Diagonal Aisle Stripping – 4" wide, 3' on center.
- E. Apply preformed thermoplastic crosswalks and stop bars, through the use of heat, in accordance with manufacturer's instructions.
- F. After applying paint, erect suitable barriers to prevent tracking of paint before drying. Retouch and paint all marking which become smeared, discolored, worn, or otherwise marred before final acceptance of the project. Remove any evidence of smearing of paint.

3.15 PAVEMENT REPAIR:

- A. If permanent pavement becomes rough or uneven, or if required by the Engineer, permanent pavement patches and trenches shall be repaired and brought to grade utilizing "infrared" paving methods following completion of the construction.
- B. The Contractor performing the work shall use care to avoid overheating the pavement being repaired.
- C. Pavement repair shall extend a minimum of 6-inches beyond all edges of the pavement patch to assure adequate bonding at the pavement joints.

3.16 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent testing agency to perform field inspections and tests and to prepare test reports.
 - 1. Testing agency will conduct and interpret tests and state in each report whether tested Work complies with or deviates from specified requirements.
- B. Additional testing, at Contractor's expense, will be performed to determine compliance of corrected Work with specified requirements.
- C. Thickness: In-place compacted thickness of hot-mix asphalt course will be tested for compliance with smoothness tolerances.
- D. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.
- E. In-Place Density: Samples of uncompacted paving mixtures and compacted pavement and will be secured by testing agency according to ASTM D 979.
 - 1. Reference laboratory density will be determined by averaging results from 4 samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 1559, and compacted according to job-mix specifications.
 - 2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
- F. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

END OF SECTION

SECTION 32 13 13

PORTLAND CEMENT CONCRETE PAVEMENT

PART 1 – GENERAL

1.1 WORK INCLUDED: Construct Portland Cement sidewalk slabs and miscellaneous items as shown on the plans or as indicated.

1.2 RELATED WORK:

A. SECTION 31 00 00 EARTHWORK

1.3 SUBMITTALS – IN ACCORDANCE WITH SECTION 01 33 00 SUBMITTAL PROCEDURES, SUBMIT THE FOLLOWING:

Design mixes for all concrete products intended for use and detailed plan and necessary drawings. Plan submitted shall indicate pour sequencing and incorporate specified time lag before pouring adjacent sections of concrete.

1.4 SPECIAL CURING REQUIREMENTS:

The Contractor shall leave concrete forms in place a minimum of five (5) days after each pour. In addition, the Contractor shall moist cure the concrete during this period.

1.5 REFERENCES:

ASTM International (ASTM)

ASTM	C31/C31M	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM	C33/C33M	Standard Specification for Concrete Aggregates
ASTM	C39/C39M	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM	C42/C42M	Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM	C88/C88M	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM	C94/C94M	Standard Specification for Ready-Mixed Concrete
ASTM	C150/C150M	Standard Specification for Portland Cement
ASTM	C171	Standard Specification for Sheet Materials for Curing

Concrete

ASTM	C226	Standard Specification for Air-Entraining Additions for Use in the Manufacture of Air-Entraining Hydraulic Cement
ASTM	C233/C233M	Standard Test Method for Air-Entraining Admixtures for Concrete
ASTM	D994/D994M	Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type)
ASTM	D1751	Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Asphalt Types)

American Concrete Institute

ACI	318	Building Code Requirements for Structural Concrete and Commentary
ACI	PRC-213	Guide for Structural Lightweight-Aggregate Concrete
ACI	PRC-214	Obtaining Cores and Interpreting Core Compressive Strength Results
ACI	PRC- 304	Guide for Measuring, Mixing, Transporting and Placing Concrete
ACI	PRC-305	Guide to Hot Weather Concreting
ACI	PRC-306	Guide to Cold Weather Concreting
ACI	PRC-315	Guide to Presenting Reinforcing Steel Design Details
ACI	PRC-325	Guide for Design and Proportioning of Concrete Mixtures for Pavements
ACI	PRC- 544	Guide to Design with Fiber- Reinforced Concrete

PART 2 – PRODUCTS

2.1 CONCRETE:

- A. 4500 PSI compressive strength concrete at the end of 28 days.
- B. Air Content: 6% + 1%, W/C, = 0.38, batch with high-range water reducer.
- C. Slump: 4- to 6-inches with high-range water reducer.
- D. Portland Cement: ASTM C150, Type 1, natural color. Minimum mix content 575 lbs./cy.
- E. Fine Aggregate: ASTM C33 except as noted below. Contain maximum of two percent (2%) by weight of the following: shale, schist, alkali, earth, loam, mica, coated

grains, soft and flaky particles. No more than four percent (4) clay by volume. 95% pass No. 4 sieve. Less than 3 percent (3%) pass No. 100 sieve.

- F. Coarse Aggregate: Crushed quarried stone, ASTM C33. Aggregate Size No. 57.

2.2 WATER:

Clean and free from oil, acid and injurious materials and amounts of vegetable matter, alkalis, and other salts.

2.3 WATER REDUCING AGENT:

Shall be listed on the current approved list of MassDOT.

2.4 AIR ENTRAINING AGENT:

Shall be listed on the Current Approved List of MassDOT.

2.5 NON-SHRINK GROUT:

Shall be MasterFlow Series as manufactured by Master Builders.

2.6 CONCRETE FORMS:

Wood or metal designed to support concrete at time of placement, reinforcing, placement equipment and personnel involved during pouring and finishing operations. Form design shall provide for leak-proof joints. Include bracing and shoring required to prevent deflection of joints.

2.7 FORM TIES:

- A. Exposed Concrete: Plastic cone snaptie, similar and equal to Dayton Superior; with 1-inch concrete plugs, color to be selected.
- B. Unexposed Concrete: Snap-off metal ties, designed to prevent form deflection, and prevent spalling surfaces upon removal. Portion remaining after removal shall be at least 1-inch from concrete surface.

2.8 FORM COATINGS:

Commercial formulation form-coating compounds shall not bond with, stain, nor adversely affect concrete surfaces, and shall not impair subsequent treatments, nor impede wetting of surfaces to be cured with water or curing compound.

2.9 EXPANSION JOINT MATERIAL:

1/2-inch thick ASTM D994 pre-molded expansion joint filler strips; full slab depth, except top portion shall be removable after concrete placement to accommodate sealant placement.

2.10 JOINT SEALANT:

- A. Premium grade, high performance, moisture cured, one component, polyurethane base, non-sag elastomeric sealant.
- B. Sikaflex 1A, as manufactured by the Sika Corporation, or approved equivalent.

2.11 CURING SHEET MATERIAL:

Product meeting the requirements of ASTM C-171.

2.12 BACKER ROD:

Open cell polyethylene backer rod (Denver Foam) by Bay Foam Products, Inc., or approved equivalent, unless otherwise instructed by the sealant manufacturer.

2.13 WELDED WIRE FABRIC:

As indicated on Drawings.

PART 3 – EXECUTION

3.1 TESTING:

The Contractor shall coordinate and schedule an independent testing laboratory 24 hours in advance of any concrete pours. The Contractor shall employ and pay for services for an independent testing laboratory to perform specified inspection and testing. It shall be the responsibility of the Contractor to schedule the concrete testing laboratory to be on site during all concrete pours. Reschedule planned concrete pours as necessary to ensure the on-site presence of the concrete testing laboratory. Caution: No concrete shall be installed without on-site testing by the concrete testing laboratory. The Contractor shall not be entitled to additional compensation for concrete which cannot be incorporated into the work due to the failure to schedule and have a concrete tester on site. The Contractor's independent testing laboratory shall be approved by the Engineer.

3.2 MIX PROPORTIONING:

- A. The responsibility for selection of proportions to be submitted to meet the MassDOT Specification shall be that of the concrete supplier.
- B. The proportions of ingredients shall be such as to produce a mixture which can be satisfactorily placed and consolidated by the methods to be employed.

3.3 PRODUCTION:

- A. Ready Mixed Concrete: Except as otherwise provided in these specifications, ready mixed concrete shall be batched, mixed, and transported in accordance with ASTM C94.

B. Mixing Water Control:

1. Concrete which arrives at the site with slump below that suitable for placement may be adjusted by the addition of water to increase slump provided that the maximum slump is not exceeded. Any addition of water to increase slump shall be followed by mixing of at least 30 revolutions of the drum.
2. After adjustment to the proper slump, discharging shall be allowed for as long as the concrete retains its workability without the addition of water.

3.4 INSTALLATION:

A. Forms

1. Forms, cores, molds, etc. shall be constructed so that the finish concrete will conform to the shapes, lines, grades, and dimensions indicated on the drawings. All forms shall remain in place for a minimum of 120 hours after completion of all concrete work, including finish work.
2. Slots, chases, recesses, inserts, keys and temporary openings:
 - a. Box out for all slots, chases, recesses, or openings as shown on the drawings and as required by the work of all other trades.
 - b. Build bulkheads with keys in walls and footings for stopping concrete. Keys shall be clean, reused or new chamfered 2 x 4's.
 - c. Box out for all temporary openings such as shafts, pipe spaces, etc., and build forms to seal up when and as required.
 - d. Build into concrete all inserts, anchors, PVC or metal reglets, ties, hangers, collars, sleeves, thimbles, sockets, nailing blocks, miscellaneous and ornamental iron as required to secure the work of other trades.
 - e. General - Ample opportunity and full cooperation shall be given to the various trades and other contractors to install their required embedded items. Suitable templates or instructions, or both, will be provided for setting such items as are not placed in the forms by the trades themselves. Openings in floor slabs shall be provided for pipes, ducts, etc., prior to or at the time of placing the form work. All embedded items shall be subject to inspection by the Engineer before concrete is placed.

B. Preparation for Placing Concrete

1. Notify the Engineer 24 hours in advance of the beginning of the following stages of work:
 - a. Final grade for slab bearing.
 - b. Pouring concrete slabs, foundations or walls.
 - c. Schedule date and time of pour with Owner's concrete testing laboratory.
2. Remove water from excavations or forms before depositing concrete. Divert any water flow through proper side drains. Remove without washing over freshly deposited concrete, debris, foreign materials from form interiors, from mixing, conveying equipment inner surfaces.
3. Provide runways or other means for wheeled equipment to convey concrete to deposit points. Do not wheel equipment used to deposit concrete over reinforcement. Do not support runways on reinforcement.
4. Spray existing concrete surfaces with water to a surface saturated condition prior to pouring concrete.

C. Placing Concrete:

1. Re-tempered concrete shall not be allowed. Air-slaked or lumpy concrete shall not be used. The contents of the mixer shall be completely discharged before each new batch is loaded.
2. In form work, spade or vibrate thoroughly to ensure contact with concrete. Tamping shall be done with an internal mechanical vibrator. Vibrators shall not be used to move or flow concrete.
3. No honeycombed work will be accepted.
4. Vertical and/ or horizontal plumb bulkheads with keys shall be used at joints (locations shown on plans) for ending day's work and arranged at right angles to planes of stress and in areas of minimum shear. Provide water stop(s) where water tightness is required as shown on the plans. Water tightness is required for structures designed to contain fluid.
5. Concrete shall be placed in lifts not to exceed 18-inches.
6. Continuous vibration shall be used with the interval of insertion not to exceed 18-inches in any direction.
7. Placing shall be performed to prevent the forming of cold and/or irregular joints.
8. No free fall of concrete over 4'-0" will be permitted.
9. Maximum concrete pours shall be as follows:

Slabs: 25' maximum dimension, 600 sq. ft. maximum area, maximum length to width ratio of 2.

Walls: 30' adjacent concrete shall not be placed for a period of five (5) days, unless otherwise indicated. Note requirements for leaving forms in place under paragraph 3.11.

3.5 CONSTRUCTION JOINTS, CONTROL JOINTS AND EXPANSION JOINTS:

- A. All joints shall be formed, and caulked joints made at such locations shown on plans as will least impair the strength of the structure, and as may be required by the Engineer.
- B. Furnish and install keying and supplementary reinforcement at each construction joint and stoppage. Install water stops as shown on plans, as required for watertight structures or as required by Engineer.
- C. Before pouring the next section, clean exposed reinforcement, clean and roughen exposed concrete and slush with neat cement grout.
- D. Install expansion joint material at all locations where new concrete is cast against existing structures, walls, etc. Install expansion joints at 20' intervals within all new walks and as shown on the Contract Drawings, other than the above noted structures, walls, etc.
- E. Construct control joints, in slabs, at the locations shown on the drawings or at 5-foot intervals in each direction.

3.6 TOLERANCES:

- A. Unless otherwise indicated, all concrete work to be faced with other materials shall have a tolerance not to exceed 1/4-inch as measured on a ten-foot straight edge.
- B. If any concrete varies beyond tolerances indicated, Contractor may be required to grind it down at no extra cost. Ground surface may require surface treatment. Provide required treatment as ordered by Engineer at Contractor's expense.

3.7 PATCHING CONCRETE:

- A. Immediately after removal of forms, patch all holes including those at form ties, honeycombing, and other voids in concrete surfaces. Remove all fins and other projections on concrete surfaces.
- B. Wet the surface to be patched and patch with stiff mortar of one-part Portland cement to two parts sand. All exposed surfaces: The cement portion shall be one-part white Portland and one-part regular cement. Sand shall pass #30 sieve. Permit patching grout, before use, to set 20 to 30 minutes and re-temper without adding additional water.
- C. Compact mortar thoroughly into place and screed it off a little higher than adjacent work and finish flush after initial set.
- D. Work that cannot be properly patched, in the opinion of the Engineer, shall be rejected.

3.8 SLABS ON GRADE:

- A. Construct structures as shown on the drawings. Include all material, forms, etc. required.
- B. Compacted porous fill shall be placed before installing concrete slabs which bear on the ground. See applicable specifications and details on plans. Place vapor barrier over gravel base as shown on plans.
- C. Upon the prepared base, place a monolithic concrete slab, reinforced as indicated.

3.9 CONCRETE FINISHING:

- A. No concrete finishing operation shall be conducted while there is free water on the surface, and no dusting of cement, sand or cement-sand mixture is to be used to dry up the surface water on the concrete. Power finishing tools may be used except that area adjacent to electrical trench header ducts, vertical surfaces, electrical fittings, etc. shall be hand finished.
- B. All concrete slabs shall be, after finishing, true and level to within 1/8-inch of 10' unless indicated to have drainage slopes. Remedial action at the Contractor's expense may be required, at the Engineer's discretion, for any slab not meeting the above standards.
- C. Should spalling occur in surface of concrete, the slab shall be removed and replaced at the Contractor's expense. Patching the surface of the concrete after initial set has taken place will not be accepted.

3.10 SPECIFIC SLAB FINISHES:

- A. All slabs shall receive the following preliminary finish:
 - 1. Bring the concrete to the correct level and, at the proper times, screed, darby and float with a magnesium float. Additional operations shall be applied as indicated.
- B. Broom Finish (Final): Provide a medium broom finish or as noted on the plans, where broom finish is scheduled.
- C. Trowel Finish (Final): All other slab surfaces: Immediately following floating, steel trowel, steel trowel a second time at the proper time for a dense, hard surface.

3.11 PROTECTION AND CURING:

- A. General
 - 1. The following rules are for the minimum requirements of protection only and the Contractor shall remain fully responsible to produce concrete which has not been weakened or injured on the surface by frost or freezing or by incomplete protection during hot weather.
 - 2. Protection shall consist of heating the materials, fully enclosing the concrete, and maintaining the temperature of the enclosure at not less than 50° F. for five (5) days.
 - 3. Aggregates and water shall be heated to not more than 140° F. and the concrete shall not be less than 50° F, nor more than 90° F. when deposited.
 - 4. Contractor shall provide adequate protection during hot weather against rapid drying and cold joints. Accelerating, retarding, or anti-freeze admixtures will not be permitted. Provide facilities necessary for moist curing.
 - 5. Prevent use of concrete for a period of five (5) days after installation.
 - 6. Forms shall be left in place a minimum of 120 hours after completion of each pour.
- B. Cold Weather Concreting
 - 1. When placing concrete at or below a temperature of 40° F., or whenever atmospheric temperatures will probably fall below this limit within the next 24 hours and after placing concrete, the mixing water and aggregates shall be heated, and the freshly placed concrete protected by adequate housing or covering and heating.
 - 2. The Contractor shall have on the job ready to install adequate equipment for heating the materials and for maintaining the proper temperatures and atmospheric moisture for the freshly placed concrete, and for enclosing the work in accordance with the requirements specified herein. Do not use salamanders or open fires. Submit diagrams showing the type of equipment to be used and how it will be placed in order to maintain proper temperatures required during cold weather concreting for approval of the Engineer.
 - 3. Either aggregates or water or both, as may be necessary, shall be heated with steam coils or other approved devices so that the average temperature of the concrete as it is deposited in a form shall fall within the limits specified herein.

Aggregates containing frozen lumps shall be independently heated and no materials containing frozen lumps, ice or snow shall be allowed to enter the mixer.

4. Before placing the concrete in any form or on any surface, or around any reinforcement, heat shall be applied in such a manner that ice or snow will be completely removed, and the reinforcement will be at the same temperatures as the concrete being placed. No concrete shall be placed on a subgrade that is frozen or on one that contains frozen materials.
5. Concrete, when placed in the forms, shall have a temperature of not less than 70° F. and not above 80° F. Freshly placed concrete shall be maintained at a temperature of not less than 50° F. for five (5) days for normal concrete, and not less than 50° F. for three (3) days for high early strength concrete. Cooling of the concrete to outside temperatures shall not be at a rate faster than one (1) degree each hour for the first day, and two (2) degrees each hour thereafter.
6. The use of salts, chemicals, or other foreign materials in the mix to lower the freezing point of the concrete is prohibited.
7. Before concreting any section of a structure, the section shall be completely housed or enclosed in a manner that will ensure the maintenance of the specified temperatures. The housing shall be left in place for the curing period specified except that sections may be temporarily removed as required to accommodate the placing of column forms or concrete provided that they are replaced immediately after the form or concrete is in its final position.
8. A permanent temperature record shall be kept showing the date, hour, outside temperature, and temperatures at several points within the enclosure to show the most favorable and unfavorable condition to which the concrete is subjected. Thermometer readings will be taken at the start of the work in the morning and again in the late afternoon and the data so obtained shall be recorded in such manner that it will show the location of each reading and any conditions which might have an effect on the temperature. A copy of the temperature records shall be furnished to the Engineer upon request.

C. Hot Weather Concreting

1. Hot weather, for the purposes of this specification, shall be defined as 80° F. and rising, or 85° F. and falling.
2. During hot weather, Contractor shall plan for prompt placement by assuring an adequate number of personnel to handle and place concrete, and it shall provide adequate protection during finishing and during operations.
3. Forms, reinforcing subgrade should be sprinkled with cold water just prior to concrete placement.
4. Concrete with a temperature exceeding 90° F shall not be placed, and an attempt shall be made to keep the concrete temperature well below 90° F. Contractor shall check the temperature of concrete just prior to placement and after placement. This information shall be recorded together with the location where the concrete was placed.
5. Cooling of concrete materials before mixing and during mixing using methods as recommended by the American Concrete Institute shall be adhered to.

6. Concrete shall be placed as soon as possible after mixing and/or delivery. On flat work, all finishing operations should be conducted promptly.
7. Protection and Curing: Exposed surfaces shall be protected from accelerated drying by using continuous water curing methods and surfaces shall be kept moist for at least 120 hours. On flat slab or other work exposed to wind or other evaporating conditions, surfaces shall be protected by wet sand or sisal-kraft paper. If water is used directly on new surfaces, the temperature of water should not be much cooler than the concrete.
8. Test of concrete conducted during hot weather shall be in accordance with latest ACI and PCA Standards and/or recommendations.
9. During hot weather, a log shall be kept indicating air temperature, weather condition, relative humidity, and temperature of concrete before and after placement. These tests shall be conducted at frequent intervals and as required by the Engineer.
10. Admixtures to delay setting time will not be permitted.

D. Curing

1. Concrete shall be protected against loss of moisture, rapid drying, or temperature changes, mechanical injury, or injury from rain or flowing water for a period of seven (7) days. Concrete shall be maintained above 50° F., and in a moist condition during curing period.
2. Curing shall commence as soon as free water has disappeared from the surfaces after finishing. Curing of formed soffits of beams, girders, floor slabs, and similar surfaces shall be accomplished by moist curing with forms for full curing period.
3. Except where specified methods of curing are specified, curing may be accomplished by any one of the following methods:
 - a. Moist Curing: Surfaces shall be kept continuously wet by covering with burlap, mats, or sand, thoroughly saturated with water and covering kept wet by spraying or hosing. Place materials to provide complete surface coverage and lap all joints minimum 3-inches.
 - b. Impervious-Sheeting Curing: Surfaces shall be thoroughly wetted with a fine spray of water and then covered with waterproof paper, polyethylene sheeting, or polyethylene coated waterproof paper. Edges and ends of sheeting shall be overlapped not less than 4-inches and securely cemented or taped to form a continuous cover. Sheeting shall be weighted down to prevent displacement and shall be repaired or replaced if torn, damaged, or removed during the curing period. Under this curing method, the surface of the concrete shall always be covered with a water film. Spray concrete surface periodically to ensure that at no time will concrete cure under "dry" conditions.
4. Concrete curing of exposed floor slabs shall incorporate one of the two methods described above. Use of a concrete cure, seal agent is not acceptable for curing exposed floor slabs or sidewalks. Use of this product for sealing and/or curing in other locations may be allowed at Engineer's discretion.

3.12 CONCRETE TESTING STANDARDS:

A. ASTM International

1. Method of making and curing concrete compression and flexure test specimens in the field.
2. Method of test for compressive strength of molded concrete cylinders.
3. Method of test for securing, preparing and testing specimens from hardened concrete for compressive and flexural strengths.
4. Method of test for weight per cubic foot, yield, content (gravimetric) of concrete.
5. Method of test for slump of Portland cement concrete.
6. Standard method for sampling fresh concrete.
7. Method of test for air content of freshly mixed concrete by the volumetric method.
8. Method of making and curing concrete compression and flexure test specimens in the laboratory.
9. Method of test for air content of freshly mixed concrete by the pressure method.

3.13 CONCRETE TESTS:

- A. During the progress of the work, compression test specimens shall be made and cured in accordance with ASTM C31. Not less than five specimens (2 for 7 day, 2 for 28-day tests and one spare specimen) shall be made for each test, nor less than one test for each 50 cubic yards of concrete of each class or fraction thereof placed in one day. Specimens shall be cured under laboratory conditions. Except that when, in the opinion of the Engineer, there is a possibility of the surrounding air temperature falling below 40° F., and it may require additional specimens to be cured under job conditions. Cost for laboratory tests for compression test cylinders shall be borne by the Contractor.
- B. Specimens shall be tested in accordance with the standard method of test for compressive strength of molded cylinders (ASTM C39/C39M).
- C. Slump tests shall be conducted for each individual concrete batch or as frequently as may be required to assure that no concrete shall have more than the required slump. All tests shall be conducted in the presence of the Engineer. Tests shall be performed in accordance with ASTM requirements. Tolerance is +1/2".
- D. Entrained air tests for air-entrained concrete shall be conducted every hour and/or as frequently as may be required to assure that the concrete shall contain the air content specified. All tests will be conducted in the presence of the Engineer, and testing of each batch will be done by the same representative of the testing laboratory. Take tests at the point of placement for pumped concrete.
- E. All cylinders, air content test, and slump tests shall be made by qualified personnel acceptable to the Engineer.
- F. The standard age test shall be 28 days, but 7-day tests may be used provided that the relation between 7-day and 28-day strengths of the concrete is established by

tests for materials and proportions used. If 28-day tests fall below the compressive strengths called for in the specifications, the spare test cylinder shall be broken at 56 days as a final check.

- G. If the average strength of the laboratory-cured field cylinders for any portion of the structure falls below the compressive strengths called for in the specifications, the Engineer may require tests in accordance with ASTM C42/C42M or order load tests to be made on the portions of the building so affected. Costs for hardened concrete tests and load tests shall be borne by the Contractor.
- H. If the average strength of the laboratory-cured field cylinders falls below the compressive strength called for, the concrete covered by these tests shall be assumed as inadequate for the structure and the Engineer may require that load tests be placed on the portions of the structure in question. Loading shall be in accordance with ACI 318, and the method of loading and conducting the test shall be submitted in advance to the Engineer for its approval. If the tested portion of the structure does not fulfill the requirements of the test, it shall be deemed to have failed and shall be removed and replaced. The Engineer reserves the right to reject sub-standard concrete work as indicated by hardened concrete field cylinders regardless of the load tests.
- I. The laboratory shall furnish copies of all tests as follows:

Engineer:	1 copy
General Contractor:	2 copies
Concrete Supplier:	1 copy
- J. At the end of the week, the Contractor shall submit to the Engineer a record showing the results of all slump and air tests made during the previous week. This record shall indicate the location in the project where this concrete was used.

3.14 EVALUATION AND ACCEPTANCE:

- A. Evaluation: Test results of standard cylinders, molded, cured and tested according to ASTM C31/C31M and C39/C39M, shall be evaluated separately for each concrete mix according to ACI PRC-214.
- B. Acceptance: The criteria for acceptance of concrete shall be detailed in ACI 318.

END OF SECTION

SECTION 32 14 00

BRICK PAVERS

PART 1 - GENERAL

1.1 WORK INCLUDED:

- A. The Contractor shall furnish all necessary labor, materials, equipment, transportation and services necessary to complete the work of this Section as specified herein, as shown on the drawings, or both.
- B. The work of this Section includes, but is not limited to the following:
 - 1. Setting bed, concrete base, and subbase
 - 2. Brick Unit Pavers, new and salvaged

1.2 RELATED WORK

- A. Section 01 33 23, SUBMITTALS
- B. Section 31 00 00, EARTHWORK
- C. Division 04, MASONRY

1.3 SUBMITTALS

- A. Manufacturer's Product Data: Manufacturer's product data shall be submitted for the brick pavers.
- B. Test results from an independent testing laboratory for compliance of paving unit requirements to ASTM C 936 and CSA A231.2-95 for resistance to freeze-thaw and or other applicable requirements.
- C. Sieve analysis for grading of bedding/aperture/joint sand.

1.4 SAMPLES

- A. Prior to ordering any materials, the Contractor shall submit representative brick samples to the Owner's Representative for selection and approval. Do not order materials until Owner's Representative's approval has been obtained. Delivered materials shall exactly match the approved samples.

- 1. Brick Pavers

The Contractor shall submit six (6) brick samples to show the texture, finish, and full range of color variation that can be expected in the finished work.

2. Brick Paver Sample Panels

Construct one (1) sample panels at locations as required by the Owner's Representative. The sample panel shall consist of both new brick pavers and salvaged brick pavers, blended in such a way to evenly disperse the colors and match the adjacent sidewalks / pathways.

The sample panels shall encompass twenty-five (25) square feet and be located by the Owner's Representative. The Owner's Representative must approve the quality of workmanship before permanent brick pavement construction is started. If the sample is not approved, the Contractor shall provide additional samples, as required, at no cost to the Owner until an approved sample is obtained. The approved samples shall become the standard for brick pavement throughout the entire job. The sample panels should be constructed in a location that ultimately becomes a part of the final pavement and shall remain undisturbed until all paving is completed.

1.5 SHIPPING AND HANDLING OF MATERIALS

- A. Notwithstanding any prior acceptance of materials given prior to delivery, acceptance and approval for all work will be based upon the conditions at completion of installation.
- B. It is the responsibility of the Contractor to exercise all necessary precautions to properly protect materials. Where damage occurs the items will be rejected.
 - 1. Brick pavers shall be packaged and delivered/off-loaded to manufacturer's standards. Pavers damaged in any manner will be rejected and shall be replaced with new material at no additional cost to the Owner.
 - 2. Store all brick pavers, both new and salvaged, on raised platforms in such a manner as to prevent damage or intrusion of foreign matter. Storage piles or stacks shall be located to avoid damage and be protected from heavy and unnecessary traffic. Materials shall be stored under an approved roof or covered with waterproof tarpaulins, at all times, except when men are working and using the materials.

1.6 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. Construction methods, transportation and delivery of mixtures, spreading, finishing, compaction joints, etc. shall conform the Section 460 of the Massachusetts Department of Transportation, Standard Specifications for Highways and Bridges unless otherwise specified herein.
- C. Traffic Control: Maintain access for vehicular and pedestrian traffic as required and for other construction activities.

- D. Grade Control: Establish and maintain required lines and elevations.

1.7 REGULATORY REQUIREMENTS

- A. Strictly comply with applicable codes, regulations and requirements of authorities having jurisdiction.

1.8 QUALITY ASSURANCE

- A. Installer must review installation procedures of all brick paving and sequence of work with General Contractor to ensure proper coordination with other subcontractors and suppliers whose work is affected by the delivery schedule and installation of paving work.
- B. Paver manufacturer shall be an ICPI Certified Producer.
- C. Installation shall be by a contractor and crew with at least five years experience in placing concrete pavers on projects of similar size and scope.
- D. Contractor shall conform to all local, state licensing and bonding requirements and shall have received a Record of Completion of the ICPI Commercial Paver Technician Course or be an ICPI Certified Contractor.
- E. Do not install subbase or base materials, or pavers, during heavy rain or snowfall. Do not install subbase or base or pavers over frozen materials.

1.9 COORDINATION

- A. This Contractor shall coordinate with all other trades especially grading, curb installation, electrical and plumbing contractors, through the General Contractor in order to prevent covering up unfinished or uninspected work and loss of time or labor by mis-scheduling and to assure the steady progress of all work of the Contract. 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 to remain shall be protected from damage by construction activities to the extent possible. Where sections of the finished paved areas have to be removed, the edges shall be saw cut in all cases and patched.
- 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. These resurfaced areas shall be large enough to be applied by paving machines. 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 CEMENT CONCRETE MORTAR

- A. Cement concrete for use in the keying of all brick pavers shall be as specified under Section 03 30 00 CAST IN PLACE CONCRETE. Mortar color shall match existing and shall be verified with the Owner's Representative prior to installation.

2.2 CEMENT CONCRETE PAD

- A. Cement concrete for use as a base below brick pavers shall be a single pour in accordance with Section 03 30 00 CAST IN PLACE CONCRETE.

2.3 BRICK PAVERS

- A. Brick pavers shall meet ASTM C 936.
- B. Dimension of brick pavers shall be 4" wide, 8" long, and 2-1/4" thick, or approved equal.
- B. Brick pavers shall be wire cut. Refer to drawings for pattern and location.
- C. The required number of the pavers shall be determined by the Contractor based on the square footage identified on the plans for the particular item.
- D. All pavers shall have a minimum compressive strength of 8,000 pounds per square inch.
- E. Water absorption shall be 5 percent or less when tested in accordance with ASTM C 140 with no individual stone testing more than 7 percent.
- F. Contractor to provide Owner's Representative with samples of new brick material and color for approval.
- G. Acceptable manufacturers include:
 - 1. Pine Hall Brick Company, Inc. (800) 334-8689
 - 2. The Belden Brick Co., Tel: (330) 451-2031
 - 3. Endicott Brick, Tel: (402) 729-3315
 - 4. Or approved equal

2.4 SAND FOR JOINT FILLER

- A. Joint filler between paver joints shall be a polymeric sand meeting ASTM C144. Sand mixture shall contain coloring additive to match joint filler mixture with color of brick pavers.
 - 1. Color of joint filler shall match the color range of the brick paver and shall be approved by the Owner's Representative.
 - 2. Sand shall be HP2 Polymeric Sand manufactured by Techniseal, 300 Liberte Avenue Quebec, Canada or approved equal.

2.5 WATER

- A. Water shall be potable and shall be free of injurious contaminants.

PART 3 - EXECUTION

3.1 MORTAR SETTING BED

- A. After the concrete and gravel bases have been installed to the appropriate grades, place mortar to achieve the specified compacted depths.

3.2 SETTING BRICK PAVERS

- A. Brick pavers shall be set on a mortar setting bed over a prepared concrete base. Setting bed shall be protected from damage prior to setting pavers.
- B. Brick pavers with chips, cracks, stains, or other structural or aesthetic defects shall not be used.
- C. Brick shall be laid in a running bond pattern.
- D. Only competent workmen under adequate supervision shall perform the work of setting concrete pavers. Set pavers in accordance with manufacturer's recommendations. Concrete pavers shall be set true to the required lines and grades in the pattern detailed on the Contract Documents.
- E. After the modified asphalt adhesive is applied, pavers shall be carefully placed by hand, set true to the required lines and grades in the pattern shown on the Contract Documents. Accurate alignment shall be maintained. The Owner's Representative will approve the start of paving layouts.
- F. Pavers shall be neatly cut and fitted at all perimeters and closures to fit neatly and closely. Pavers shall be tightly butted. Joints between pavers shall be uniform and shall not exceed 1/8 inch in width. Joints greater than 1/8 inch in width will not be accepted. Surface edge of one paver shall be level with the next adjacent pavers so that no voids, rocking motions, or tripping hazards are encountered. There shall be no deviation from a true grade greater than 1/4 inch in 10 feet. All finish paved areas shall slope to drain at a minimum of 1/8 inch in 1 foot.

- G All cutting and patching required to complete the work shall be done (including the filling and closing of all openings) with water-cooled radial cut-off type masonry saws with diamond-tipped blade for a sharp, straight edge. Cut edges shall be plumb and straight. Scoring and breaking will not be acceptable.
- H. After cutting of pavers, grind all cut edges of top surfaces of pavers to create a beveled, 45 degree angle equal to the manufacturer's bevel. Ground bevels shall be straight and true and shall be accomplished using a sufficiently fine grinding wheel or blade to prevent apparent grind marks on the bevels.
- I. After a sufficient area of pavers has been installed, joints of pavers shall be filled by sweeping sand into the joints, as specified, performed and paid for under this Section.
- J. Completed surface shall be compacted by running a medium plate vibrator across the top of the pavers. Additional joint filler material shall be swept in the joints during vibration to completely fill joint space.
- K. Newly laid pavers shall be protected at all times by panels of plywood. These panels may be advanced as work progresses; however, the plywood protection shall be kept in areas which will be subjected to continued movement of materials and equipment. All necessary precautions shall be taken in order to avoid depressions and protect paver alignment.

3.3 JOINT TREATMENT

- A. Joint filler shall be swept dry into the joints between pavers until the joints are completely filled. Surface shall be swept clean. Swept surface shall then be thoroughly dampened with a low-volume fine spray of water.
 - 1. Sweep sand into paver joints until joints are filled solid. Fog lightly with water and repeat a minimum of three times or until joints are compacted and full.
 - 2. Prior to acceptance, the paved area shall be flooded with water to assure that there are no depressions. Pavers with top surfaces greater than 1/16 inch above or below adjacent pavers shall be removed and reset. Remove and reset pavers as required until surface is true to line and grade. Refill sand joints as necessary until all joints are filled to finish grade.
- B. Brick paving shall be kept damp by intermittent spraying for three days, minimum, to effectively cure the joints.
- C. Mortar Joints
 - 1. Spread and screed to uniform thickness, except for minor variations required to produce a true surface, level in plane or uniformly sloped for drainage as shown. Cut back, bevel edge, remove and discard setting bed material which has reached initial set prior to placing of paver units.
 - 2. Wet brick units several hours before laying, unless their gain in weight resulting from partial immersion flatware in 1/8" of water for 1 minute is less than 3/4 oz.

per 30 sq. in. of immersed area. Do not lay bricks with free moisture on the surface.

3. Grout joints as soon as possible after initial set of setting bed. Force grout into joints, taking care not to smear grout on adjoining paver units and other surfaces. After initial set of grout, finish joints by tooling to produce a very slightly concave polished joint, free from drying cracks.
4. Cure grout by maintaining in a damp condition for 7 days.

D. Repair and Pointing:

1. Remove and replace brick pavers which are loose, chipped, broken, stained or otherwise damaged, or if units do not match adjoining pavers. Provide new pavers to match adjoining pavers and install in fresh mortar, pointed to eliminate evidence of replacement.
2. Pointing: During the tooling of joints, enlarge voids of holes and completely fill with mortar.

3.4 CLEANING OF BRICK PAVER SURFACES

- A. After completion of concrete paving, surfaces shall be carefully cleaned, removing all dirt, excess filler, and stains.
- B. Clean pavers using an approved masonry cleaner and soft bristle brush.

3.5 GUARANTEE

- A. The Contractor shall guarantee all pavement 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 condition.

END OF SECTION

SECTION 32 16 00

CURBING

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This section covers furnishing and installation of granite curb, where required, as shown on the Drawings and herein specified.
- B. This section also covers replacement of curbing removed during construction.

1.2 RELATED WORK

- A. Required earthwork is specified under Section 31 00 00 EARTHWORK.
- B. Section 32 11 00, SIDEWALK CONSTRUCTION AND REPLACEMENT
- C. Section 32 12 16, HOT MIX ASPHALT PAVING

1.3 REFERENCES

The following standards form a part of these specifications, as referenced:

Massachusetts Department of Transportation (MassDOT) Standard Specifications for Highways and Bridges

1.4 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 00 SUBMITTAL PROCEDURES, SUBMIT THE FOLLOWING:

Shop drawings, showing dimensions of typical curb sections.

PART 2 - PRODUCTS

2.1 GRANITE CURBING:

- A. Granite curbing shall be Type VA4 conforming to Subsection M9.04.1 of the latest edition of the MassDOT Standard Specifications for Highways and Bridges.
- B. Special shapes and corners shall be supplied as required.

PART 3 - EXECUTION

3.1 GRANITE CURBING:

- A. Removal and resetting and/or removal and replacing of granite curbing shall be in accordance with Subsection 580 of the latest edition of the MassDOT Standard Specifications for Highways and Bridges. The curbing shall have a 6-inch reveal unless otherwise required by the Engineer.

- B. Except as modified herein or on the drawings, installation of curbing shall conform to Section 500 of the MassDOT Standard Specifications for Highways and Bridges.
- C. Excavation shall be made to the bottom of the 6-inch gravel base below the curbing, the trench being sufficiently wide to permit thorough tamping. The base shall be compacted to a firm, even surface and shall be approved by the Engineer.
- D. The curbing shall be set on edge and settled into place with a heavy wooden hand-rammer, to the line and grade required, straight and true for the full depth. The joints of the stone curbing shall be pointed with mortar for the full depth of the curbing. At approximately 50-foot intervals, a 1/2-inch joint shall not be filled with mortar but left free for expansion. The ends of the stone curbing at driveways and intersections shall be cut at a bevel or rounded as required by the Engineer.
- E. The trench for the stone curbing shall be backfilled with approved material; the first layer to be 4 inches in depth, thoroughly rammed; the other layers to be more than 6 inches in depth and thoroughly rammed until the trench is filled.
- F. Where indicated on the plans, or as required, drainage openings shall be made through the curbing at the elevations and of the size required.

END OF SECTION

SECTION 32 31 13.53

CHAIN LINK FENCE

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings, quality, product and performance requirements, general and supplemental conditions apply as applicable to the project and project documents.

1.2 WORK INCLUDED

- A. This Section includes materials and installation requirements applicable for high security chain link fence and gates. Refer to CLFMI SFR 2445, "Security Fence Recommendations", ASTM F2781 "Standard Practice for Testing Forced Entry, Ballistic, and Low Impact Resistance of Security Fence Systems" and CLFMI CLF-TPO211 "Tested and Proven Performance of Security Grade Chain Link Fence Systems"
 - 1. Galvanized steel coated chain link fabric
 - 2. Galvanized steel framework and fittings
 - 3. Installation

1.3 RELATED WORK

- A. 01 33 00, SUBMITTAL PROCEDURES
- B. 03 05 00, FIELD CONCRETE

1.4 REFERENCES

ASTM International (ASTM)

ASTM	A121	Standard Specification for Metallic-Coated Carbon Steel Barbed Wire
ASTM	A392	Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric
ASTM	A780	Standard Practice for Repair of Damaged and Uncoated Areas of Hot- Dip Galvanized Coatings
ASTM	A824	Standard Specification for Metallic-Coated Steel Marcellled Tension Wire for Use with Chain Link Fence
ASTM	F552	Standard Terminology Relating to Chain Link Fencing
ASTM	F567	Standard Practice for Installation of Chain Link Fence
ASTM	F626	Standard Specification for Fence Fittings
ASTM	F668	Standard Specification for Polyvinyl Chloride (PVC), Polyolefin and Other Polymer Coated Steel Chain Link Fence Fabric
ASTM	F900	Standard Specification for Industrial and Commercial Swing Gates

ASTM	F934	Standard Specification for Standard Colors for Polymer-Coated Chain Link Fence Materials
ASTM	F1043	Standard Specification for Strength and Protective Coatings on Steel Fence Framework
ASTM	F1083	Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated(Galvanized) Welded, for Fence Structures
ASTM	F1184	Standard Specification for Industrial and Commercial Horizontal Slide Gates
ASTM	F1664	Standard Specification for Poly (Vinyl Chloride) (PVC) and Other Conforming Organic Polymer-Coated Steel Tension Wire Used with Chain-Link Fence
ASTM	F1665	Standard Specification for Poly (Vinyl Chloride) (PVC) and Other Conforming Organic Polymer-Coated Steel Barbed Wire Used with Chain-Link Fence.
ASTM	F1910	Standard Specification for Long Barbed Tape Obstacles
ASTM	F1911	Standard Practice for Installation of Barbed Tape
ASTM	F2200	Standard Specification for Automated Vehicular Gate Construction
ASTM	F2611	Standard Guide for the Design and Construction of Chain Link Security Fencing
ASTM	F2781	Standard Practice for Testing Forced Entry, Ballistic, and Low Impact Resistance of Security Fence Systems

Chain Link Fence Manufacturers Institute (CLFMI)

CLFMI	SFR 2445	Security Fence Recommendations
CLFMI	CLF TPO211	Tested and Proven Performance of Security Grade Chain Link Fencing Systems
CLFMI	WLG2445	Chain Link Fence Wind Load Guide for the Selection of Line Post and Line Post Spacing

UL Solutions (UL)

UL 325 Door, Drapery, Gate, Louver and Window Operators and Systems

1.5 IN ACCORDANCE WITH SECTION 01 33 00 SUBMITTAL PROCEDURES, SUBMIT THE FOLLOWING:

- A. Shop drawings: Site plan showing layout of fence location with dimensions, location of gates and opening size, cleared area, elevation of fence and gates, details of attachments and footings.
- B. Certifications: Manufacturers material certifications in compliance with current ASTM specifications.
- C. Domestic certifications: Material certifications, Made in U.S.A., Buy American Act or Buy America when required.

1.6 QUALITY ASSURANCE

- A. Manufacturer: Company operating in the United States having U.S. manufacturing facility/facilities specializing in manufacturing chain link fence products with at least 5 years' experience.
- B. Fence contractor: Company with demonstrated successful experience installing similar projects in accordance with ASTM F567 at least 5 years' experience.
- C. Tolerances: Current published edition of ASTM specifications tolerances apply. ASTM specification tolerances supersede any conflicting tolerance.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Delivery: Deliver products to site per contract requirements.
- B. Storage: Store and protect products off the ground when required.

PART 2 – PRODUCTS

2.1 CHAIN LINK FABRIC

- A. Steel Chain Link Fabric: 2 in. mesh, 6 gauge per ASTM.
 - 1. Zinc-Coated Steel Fabric: ASTM A392 hot dipped galvanized after weaving.
 - a. Class 2 - 2.0 oz/ft²
 - 2. Fabric selvage: Knuckle finish top and bottom.

2.2 STEEL FENCE FRAMEWORK

- A. Round steel pipe and rail: ASTM F1043 Heavy Industrial Fence Framework. Exterior hot dipped zinc coating minimum average 1.8 oz/ft², interior hot dipped zinc coating minimum average 1.8 oz/ft². Steel yield strength 30,000 psi.
 - 1. Line post: Minimum outside diameter 2.375-in. and weighing not less than 3.12 pounds per linear foot.
 - 2. End, Corner, Pull post: Minimum outside diameter 2.875-in. and weighing not less than 4.64 pounds per linear foot.
 - 3. Top, brace, bottom and intermediate rails, 1.660-in. outside diameter and weighing not less than 1.84 pounds per linear foot.

2.3 TENSION WIRE

- A. Metallic Coated Steel Tension Wire: 7 gauge (0.177-in.) marcelled wire complying with ASTM A824.
 - 1. Type II Zinc-Coated Class 4 - 1.2 oz/ft².

2.4 FITTINGS

- A. Brace Bands and Line Rail Clamps: Galvanized pressed steel complying with ASTM F626, steel thickness 1/8-in., band width 1-in., zinc coated 1.20 oz/ft². Secure with 3/8-in. galvanized steel carriage bolts.

- B. Terminal Post Caps, Line Post Loop Tops, Rail and Brace Ends, Boulevard Clamps, Rail Sleeves: In compliance to ASTM F626, pressed steel galvanized after fabrication having a minimum zinc coating of 1.20 oz/ft².
- C. Truss Rod Assembly: In compliance with ASTM F626, 3/8-in. diameter steel truss rod with a pressed steel tightener, minimum zinc coating of 1.2 oz/ft², assembly capable of withstanding a tension of 2,000 lbs.
- D. Tension Bars: In compliance with ASTM F626. Galvanized steel one-piece length 2-in. less than the fabric height. Minimum zinc coating 1.2 oz. /ft².
 - 1. Bars for 2-in. and 1 3/4-in. mesh shall have a minimum cross section of 3/16-in. by 3/4-in.

2.5 TIE WIRE AND HOG RINGS

Tie wire and hog rings per ASTM F626. 9 gauge (0.148-in.) galvanized steel preformed power-fastened wire ties, 9 gauge (0.148-in.) galvanized steel hog rings. Minimum zinc coating 1.20 oz/ft² for ties and hog rings.

2.6 CONCRETE

Concrete for post footings as specified under Section 03 30 00 CAST-IN-PLACE CONCRETE.

2.7 PRIVACY SLATS

- A. Tubular Polyethylene Slats: Minimum 0.023-inch-thick tubular polyethylene, manufactured for chain-link fences from virgin polyethylene with UV inhibitor, sized to fit mesh specified for direction indicated, with vandal-resistant fasteners and lock strips and fins for increased privacy factor.

Color: Black

PART 3 - EXECUTION

3.1 CLEARING FENCE LINE

The contract drawings indicate the extent of the area to be cleared and grubbed (if applicable).

3.2 FRAMEWORK INSTALLATION

- A. Posts: Posts shall be set plumb in concrete footings in accordance with ASTM F567. Minimum footing depth, 24-in. plus an additional 3-in. for each 1 ft. increase in the fence height over 4 ft. Minimum footing diameter four times the largest cross section of the post up to 4.000-in. O.D. and three times the largest cross section of post greater than 4.000-in. O.D. Gate posts require larger footings; minimum requirements are listed in ASTM F567. Top of post concrete footing to be crowned to shed water away from the post. Line posts installed at intervals not exceeding 10 ft. on center.

- B. Top and bottom rail: When specified, install 21 ft. lengths of rail continuous thru the line post or barb arm loop top. Splice rail using top rail sleeves minimum 6-in. long. The rail shall be secured to the terminal post by a brace band and rail end.
- C. Bottom rail or intermediate rail shall be field cut and secured to the line posts using boulevard bands or rail ends and brace bands. For added security drill and thru bolt rail to rail ends and boulevard bands using 3/8-in. carriage bolts.
- D. Terminal posts: End, corner, pull and gate posts shall be braced and trussed for fence 6 ft. and higher and for fences 5 ft. in height not having a top rail. The horizontal brace rail and diagonal truss rod shall be installed in accordance with ASTM F567.
- E. Tension wire: Shall be installed 4-in. up from the bottom of the fabric. Fences without top rail shall have tension wire installed 4-in. down from the top of the fabric. Tension wire to be stretched taut, independently and prior to the fabric, between the terminal posts and secured to the terminal post using a brace band. Secure the tension wire to the chain link fabric with a 9-gauge hog rings 12-in. on center and to each line post with a tie wire. Install the top tension wire through the barb arm loop for fences having barbed wire and no top rail.

3.3 CHAIN LINK FABRIC INSTALLATION

- A. Chain Link Fabric: Install fabric to the outside of the framework. Attach fabric to the terminal post by threading the tension bar through the fabric; secure the tension bar to the terminal post with tension bands and 5/16-in. carriage bolts spaced no greater than 12-inches on center. Small mesh fabric less than 1-in., attach to terminal post by sandwiching the mesh between the post and a vertical 2-in. wide by 3/16-in. galvanized steel bar using 3/8-in. carriage bolts, thru bolted - thru the bar, mesh and post spaced 15-in. on center.
- B. Chain link fabric to be sufficiently stretched taut so as not to deflect more than 3-in. in the center of two line post at mid height subjected to a 30 lb. horizontal force. Fabric to be secured to the line post with tie wires spaced no greater than 12-inches on center and to rail spaced no greater than 12-inches on center using pre-formed 9-gauge galvanized steel power-fastened tie wire wrapped 360 degrees around the post or rail and fabric picket, twist the two wire ends together three full turns per ASTM F567. Excess wire shall be cut off and bent over to prevent injury. Secure fabric to the tension wire with hog rings spaced no greater than 18-inches apart. The installed fabric shall have a ground clearance of no more than 2-inches.

3.4 NUTS AND BOLTS

Bolts: Carriage bolts used for fittings shall be installed with the head on the secure side of the fence. All bolts shall be peened over to prevent removal of the nut.

3.5 CLEAN UP

The area of the fence line shall be left neat and free of any debris caused by the installation of the fence.

END OF SECTION

SECTION 32 32 13

CAST-IN-PLACE CONCRETE RETAINING WALL

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This section covers the design and construction of the cast-in-place concrete retaining wall complete, as shown on the drawings and as specified herein.
- B. The Contractor shall furnish all labor, materials, tools and equipment and shall do all work to satisfactorily construct the cast-in-place concrete retaining wall, including foundation and bedding, supervision of backfill and compaction, clean-up and all incidentals necessary to complete the work.

1.2 RELATED WORK

- A. Section 01 33 00, SUBMITTAL PROCEDURES
- B. Section 03 11 00, CONCRETE FORMS
- C. Section 03 21 00, CONCRETE REINFORCEMENT
- D. Section 03 30 00, CAST-IN-PLACE CONCRETE
- E. Section 31 00 00, EARTHWORK

1.3 QUALITY ASSURANCE

- A. The quality of materials and the finished sections shall be subject to inspection by the Engineer. Walls shall be subject to rejection at any time if they fail to meet any of the specification requirements. Any sections which are rejected, shall be promptly removed from the job site by the Contractor.

1.4 REFERENCES

- A. The following standards form a part of this specification, as referenced:

ASTM International (ASTM)

All standards included in Section 03 21 00 Concrete Reinforcement

All standards included in Section 03 30 00 Cast-in-Place Concrete

American Concrete Institute (ACI)

All standards included in Section 03 21 00 Concrete Reinforcement

All standards included in Section 03 30 00 Cast-in-Place Concrete

- 1.5 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 00 SUBMITTAL PROCEDURES, SUBMIT THE FOLLOWING:
- A. Shop drawings of the materials specified herein.
 - B. Statement of materials constituting the design of mixes which satisfy the specified strength for each size aggregate as required by ASTM C94 within one week following award of the contract.
 - C. Provide one copy of the "Certificate of Delivery" for each load of concrete as it arrives on the site, under the provisions of ASTM C94.

PART 2 - PRODUCTS

2.1 CONCRETE

- A. Concrete shall have a minimum 28-day strength of 4000 psi.
- B. Type II cement shall be used except as otherwise approved.
- C. Aggregate shall be $\frac{3}{4}$ -inch for walls less than 18-inches thick and 1-1/2-inch for walls greater than 18-inches thick.

2.2 STEEL REINFORCEMENT

- A. Steel reinforcement shall be Grade 60 and conform to ASTM A615 with a minimum of 2-inches of concrete cover over steel unless otherwise noted on the Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. The retaining wall shall be constructed to the lines and grades indicated on the drawings.
- B. Weep holes shall be provided as shown on the drawings to prevent build-up of hydrostatic pressure behind the wall.

END OF SECTION

SECTION 32 91 19

LOAMING AND SEEDING

PART 1 - GENERAL

1.1 WORK INCLUDED

This section covers all labor, materials, and equipment necessary to do all loaming, seeding and related work as indicated on the drawings and as herein specified. All lawns disturbed by the Contractor's operations shall be repaired as herein specified.

1.2 RELATED WORK

- A. Section 32 93 00, TREES, SHRUBS, GROUND COVER AND LANDSCAPING

1.3 QUALITY ASSURANCE

- A. For a particular source of loam, the Engineer may require the Contractor to send approximately 10 pounds of loam to an approved testing laboratory and have the following tests conducted:
 - 1. Organic concentration
 - 2. pH
 - 3. Nitrogen concentration
 - 4. Phosphorous concentration
 - 5. Potash concentration
- B. These tests shall be at the Contractor's expense. Test results, with soil conditioning and fertilizing recommendations, shall be forwarded to the Engineer.

1.4 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 00 SUBMITTAL PROCEDURES, SUBMIT THE FOLLOWING:

- A. Information detailing the seed mixes, fertilizers, mulch material, slope protection material (if required) and origin of loam.
- B. Test results.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. LOAM:
 - 1. Loam shall be a natural, fertile, friable soil, typical of productive soils in the vicinity, obtained from naturally well-drained areas, neither excessively acid nor alkaline, and containing no substances harmful to grass growth. Loam shall not be delivered to the site in frozen or muddy condition and shall be reasonably

free of stumps, roots, heavy or stiff clay, stones larger than 1-inch in diameter, lumps, coarse sand, noxious weeds, sticks, brush or other litter.

2. The loam shall contain not less than 4 percent nor more than 20 percent organic matter as determined by the loss of weight by ignition of oven-dried samples. Test samples shall be oven-dried to a constant weight at a temperature of 230 degrees F.

B. LIME:

Lime shall be standard commercial ground limestone containing at least 50 percent total oxides (calcium oxide and magnesium oxide), and 50 percent of the material must pass through a No. 100 mesh sieve with 98 percent passing a No. 2 mesh sieve.

C. FERTILIZER:

Fertilizer shall be commercial fertilizer, 10-10-10 fertilizer mixture containing at least 40 percent of organic nitrogen. It shall be delivered to the site in the original sealed containers, each showing the manufacturer's guaranteed analysis. Fertilizer shall be stored so that when used it will be dry and free flowing. No fertilizer shall be used which has not been marketed in accordance with State and Federal Laws, relating to fertilizers.

D. MULCH:

1. Materials to be used in mulching shall conform to the following requirements:
2. Straw Mulch shall consist of stalks or stems of grain after threshing.
3. Wood Fibre Mulch shall consist of wood fibre produced from clean, whole uncooked wood, formed into resilient bundles having a high degree of internal friction and shall be dry when delivered to the project.

E. SEED:

1. Seed shall be of an approved mixture, the previous year's crop, clean, high in germinating value, a perennial variety, and low in weed seed. Seed shall be obtained from a reliable seed company and shall be accompanied by certificates relative to mixture purity and germinating value.
2. Grass seed for lawn areas shall conform to the following requirements:

	Proportion by Weight	Germination Purity	Purity Minimum
Chewing's Fescue	30%	70%	97%
Kentucky 31 Fescue	30%	90%	98%
Kentucky Blue Grass	20%	80%	85%
Domestic Rye Grass	20%	90%	98%

Grass seed for cross-country areas, slopes and other areas not normally mowed shall conform to the following requirements:

	Proportion by Weight	Germination Minimum	Purity Minimum
Creeping Red Fescue	50%	85%	95%
Kentucky 31	30%	85%	95%
Domestic Rye	10%	90%	98%
Red Top	5%	85%	92%
Ladino Clover	5%	85%	96%

F. TEMPORARY COVER CROP:

1. Temporary cover crop shall conform to the following requirements:

	% Weight	Germination Minimum
Winter Rye	80 min.	85%
Red Fescue (creeping)	4 min.	80%
Perennial Rye Grass	3 min.	90%
Red Clover	3 min.	90%
Other Crop Grass	0.5 max.	
Noxious Weed Seed	0.5 max.	
Inert Matter	1.0 max.	

G. SLOPE EROSION PROTECTION:

1. Erosion control blanket shall be 100% degradable plastic mesh with 100% degradable straw or straw/coconut fill. Fill shall be held together by degradable fastening. Weight shall be 0.50 lb/sq. yd. Erosion control blankets shall be applied parallel to direction of water flow. The erosion control blankets shall be by North American Green, Evansville, IN or approved equal. Erosion control blanket shall be composed of 70 percent straw 30 percent coconut fiber, Model SC150BN.
2. Six-inch wire staples shall be placed according to manufacturer's recommendations to anchor the mesh material. Staples shall be designed to decompose.

PART 3 - EXECUTION

3.1 SURFACE PREPARATION

- A. After approval of rough grading, loam shall be placed on areas affected by the Contractor's operations. Loam shall be at least 6-inches compacted thickness.
- B. Lime shall be applied to bring the pH to 6.5 or, without a soil test, at the rate of 2-3 tons of lime per acre.
- C. Fertilizer shall be applied according to the soil test, or without a soil test, at the rate of 1000 pounds per acre.
- D. Loam shall be worked a minimum of 3-inches deep, thoroughly incorporating the lime and fertilizer into the soil. The loam shall then be raked until the surface is finely pulverized and smooth and compacted with rollers, weighing not over 100 pounds per linear foot of tread, to an even surface conforming to the prescribed lines and grades. Minimum depth shall be 6-inches after completion.

3.2 SEEDING

- A. Seeding shall be done when weather conditions are approved as suitable, in the periods between April 1 and May 30 or August 15 to October 1, unless otherwise approved.
- B. If there is a delay in seeding, during which weeds grow or soil is washed out, the Contractor shall remove the weeds or replace the soil before sowing the seed, without additional compensation. Immediately before seeding begins, the soil shall be lightly raked.
- C. Seed shall be sown at the approved rate, on a calm day by machine.
- D. One half the seed shall be sown in one direction and the other half at right angles. Seed shall be raked lightly into the soil to a depth of 1/4-inch and rolled with a roller weighing not more than 100 pounds per linear foot of tread.
- E. The surface shall be kept moist by a fine spray until the grass shows uniform germination over the entire area. Wherever poor germination occurs in areas larger than 3 sq. ft., the Contractor shall reseed, roll, and water as necessary to obtain proper germination.
- F. The Contractor shall water, weed, cut and otherwise maintain and protect seeded areas as necessary to produce a dense, healthy growth of perennial lawn grass.
- G. If there is insufficient time in the planting season to complete the fertilizing and seeding, permanent seeding may be left until the following planting season, at the option of the Contractor or as required by the Engineer. In that event, a temporary cover crop shall be sown. This cover crop shall be cut and watered as necessary until the beginning of the following planting season, at which time it shall be plowed or harrowed into the soil, the area shall be fertilized and the permanent seed crop shall be sown as specified.

3.3 PLACING MULCH

- A. Straw Mulch shall be loosely spread to a uniform depth over all areas designated on the plans, at the rate of 4-1/2 tons per acre, or as otherwise required.

- B. Straw Mulch may be applied by mechanical apparatus, if in the judgment of the Engineer the apparatus spreads the mulch uniformly and forms a suitable mat to control slope erosion. The apparatus shall be capable of spreading at least 80 percent of the hay or straw in lengths of 6-inches or more, otherwise it shall be spread by hand without additional compensation.
- C. Wood Fibre Mulch shall be uniformly spread over certain selected seeded areas at the minimum rate of 1,400 pounds per acre unless otherwise required. It shall be placed by spraying from an approved spraying machine having pressure sufficient to cover the entire area in one operation.

3.4 SEEDING AND MULCHING BY SPRAY MACHINE

- A. The application of lime, fertilizer, grass seed and mulch may be accomplished in one operation by the use of an approved spraying machine. The materials shall be mixed with water in the machine and kept in an agitated state in order that the materials may be uniformly suspended in the water. The spraying equipment shall be so designed that when the solution is sprayed over an area, the resulting deposits of lime, fertilizer, grass seed and mulch shall be equal to the specified quantities.
- B. A certified statement shall be furnished, prior to start of work, to the Engineer by the Contractor as to the number of pounds of limestone, fertilizer, grass seed and mulch per 100 gallons of water.
- C. This statement should also specify the number of square yards of seeding that can be covered with the solution specified above. If the results of the spray operation are unsatisfactory, the Contractor will be required to abandon this method and to apply the lime, fertilizer, grass seed and mulch by other methods.

3.5 INSPECTION AND ACCEPTANCE

At the beginning of the planting season following that in which the permanent grass crop is sown, the seeded areas will be inspected. Any section not showing dense, vigorous growth at that time shall be promptly reseeded by the Contractor at its own expense. The seeded areas shall be watered, weeded, cut and otherwise maintained by the Contractor until the end of that planting season, when they will be accepted if the sections show dense, vigorous growth.

END OF SECTION

SECTION 32 93 00

TREES, SHRUBS, GROUND COVER AND LANDSCAPING

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This Section includes furnishing all labor, materials, equipment, plants, and incidental materials necessary to perform all operations related to the planting of all trees, shrubs, vines, herbaceous plants, ground covers, and for all appurtenant work, complete in place, maintained, and accepted, in accordance with the Contract Drawings and Specifications.
- B. The Contractor shall bear the responsibility and cost of furnishing and applying water or any other substances, as necessary to ensure the sustainability of plant materials, as part of the work of this contract.

1.2 RELATED WORK

- A. Section 32 91 19, LOAMING AND SEEDING

1.3 SUBMITTALS

In accordance with requirements of Section 01 33 00 SUBMITTAL PROCEDURES, the Contractor shall submit the following:

- A. Prior to planting, State nursery inspection certificates for all plant materials.
- B. Samples of the manufacturer's product data, as applicable, for the following materials:
 - 1. Limestone.
 - 2. Fertilizer.
 - 3. Sphagnum Peat Moss.
 - 4. Humus.
 - 5. Organic Compost
 - 6. Manure.
 - 7. Mulch.
 - 8. Guying and Staking Apparatus.
 - 9. Crepe Wrapping for tree trunks.
 - 10. Anti-transpirant/Anti-desiccant.
 - 11. Insecticides.
 - 12. Herbicides.
 - 13. Fungicides.

PART 2 - PRODUCTS

2.1 PLANT MATERIALS

- A. The Contractor shall furnish and plant all plant materials as shown on the plans and in the quantities and sizes listed thereon. No substitutions shall be permitted without the written approval of the Engineer.
- B. Plants larger than those specified in the Plant List may be used if approved by the Engineer. However, use of such oversized plants shall not be considered grounds for any increase in the contract price. If the use of larger plants is approved, the required spread of roots or ball of earth shall be increased in proportion to the size of the plant and plant pits shall be increased as necessary.
- C. All plants shall be certified to have passed all required Federal and State inspection laws requiring ensuring freedom from plant diseases and insect infestations. The Contractor shall obtain clearance from applicable governing agencies, as required by law, before planting any plants delivered from outside the state in which they are to be planted.
- D. All plants shall be nursery-grown under climatic conditions and environmental stresses similar to those in the locality of the project. All plants shall originate from nurseries that are no more than one Hardiness Zone higher (as established by the Arnold Arboretum, Jamaica Plain, MA) than where the plant is to be installed. Plants also shall conform to the botanical names and standards of size, culture, and quality for the highest grades and standards as adopted by the American Hort in the American Nursery Stock Standard, Z60.1, latest edition. All plants shall be legibly tagged with their proper botanical name.
- E. No heeled-in plants or plants from cold storage shall be used. All plants shall be typical of their species or variety and shall have a normal habit of growth. Plants shall be sound, healthy, and vigorous, well branched and densely foliated when in leaf; shall be free of disease, insects, eggs or larvae; and shall have healthy, well-developed root systems. All parts of the plant shall be moist and shall show active green cambium when cut.
- F. All nursery plants shall be balled and burlapped or container-grown and shall have been acclimatized for at least one growing season. Container-grown stock shall have been grown in a container long enough for the root system to have developed sufficiently to hold its soil together, firm and whole, after removal from the container. No plants shall be loose in the container. Container-grown plants shall have no girdling roots and shall not be in a root-bound condition. Plants shall remain in their container until planted.
- G. Care shall be exercised in digging and preparing field-grown plants for shipment and planting. Balled and burlapped materials shall have solid unbroken balls of earth of sufficient size to encompass all fibrous feeding roots necessary to ensure successful recovery and development of the plants. Balls shall be firmly wrapped in untreated biodegradable burlap and tied securely with wire cages and/or jute twine. Roots or balls of plants shall be adequately protected at all times from sun and drying winds. No plant shall be accepted when the ball of earth surrounding its roots has been badly cracked or broken preparatory to or during planting, or after the burlap, staves, wire cage, rope, or platform in connection with its transplanting have been removed. Soil characteristics (i.e., composition, texture, pH, etc.) of all field-grown plants shall closely match those of the soil where plant materials are to be planted.

- H. The height of the trees, measured from the crown of the roots to the top of the top branch, shall not be less than the minimum size designated in the Plant List in the Drawings. The branching height for deciduous trees installed adjacent to or within walks shall be 7 feet minimum, having been pruned to this height at least 1 year prior to transplanting. Except when a clump is designated, the trunk of each tree shall be a single trunk growing from a single, unmutilated crown of roots. No part of the trunk shall be conspicuously crooked as compared with normal trees of the same variety. The trunk shall be free from sunscald, frost cracks, or wounds resulting from abrasions, fire, or other causes. All pruning cuts shall comply with acceptable horticultural practices. No pruning wounds having a diameter of more than 1½-inches shall be present. Any such wounds must show vigorous bark growth on all edges. Evergreen trees shall be branched to within 1 foot of the ground. No tree that has had its leader cut or die shall be accepted.
- I. Caliper measurements for tree trunks shall be taken 6-inches above ground for trees up to and including 4-inch caliper size and at 12-inches above ground for larger sizes.
- J. Shrubs shall meet the requirements for spread and/or height stated in the Plant List on the Drawings. The measures for height are to be taken from the crown or root flare to the average height of the top of the shrub mass (not the longest branch). The fullness of each shrub shall correspond to the trade classification "No. 1". Single stemmed or thin plants will not be accepted. The side branches must be generous, well-twiggged and the plant as a whole must be well-bushed to the ground. The plants must be in a moist, vigorous condition, free from dead wood, bruises or other root or branch injuries
- K. Herbaceous plants, vines and groundcovers shall be of the size, age and/or condition designated in the Plant List on the Drawings.
- L. Plants shall be delivered only after preparations for planting have been completed. Plants shall be handled and packed in a horticulturally approved manner and all necessary precautions shall be taken to ensure that plants arrive on-site in a healthy vigorous condition. Trucks used for transporting plants shall be equipped with covers to protect plants from windburn, desiccation, and overheating during transport. Plants that have not been thoroughly watered shall not be accepted at the planting site. Any plants delivered to the site in a dry or wilted condition shall be rejected and replaced at no expense to the Owner. All plant materials shall be protected, watered and otherwise maintained prior to, during, and upon delivery to the site.
- M. Plants shall be subject to inspection and approval by the Engineer at the place of growth, or upon delivery, for conformity to specification requirements as to quality, size, variety, and condition. Inspection and selection of plants before digging shall be at the option of the Engineer. The Contractor, or its representative, shall be present, if requested by the Engineer, for inspection of plants at the Nursery. Such approval shall not impair the right of inspection and rejection upon delivery at the site or during the progress of work, for size and condition of balls and roots, disease, insects and latent defects or injuries. Rejected plants shall be removed immediately from the site. Certificates of inspection of plant materials shall be furnished as may be required by Federal, State and other authorities to accompany shipments.

2.2 SOIL ADDITIVES AND AMENDMENTS

A. LIMESTONE:

Lime shall be an approved agricultural limestone containing at least 50 percent total oxides (calcium oxide and magnesium oxide). The material will be ground such that 50 percent of the material will pass through a No. 100 mesh sieve and 98 percent will pass a No. 2 mesh sieve. Lime shall be uniform in composition, dry and free-flowing and shall be delivered to the site in the original sealed containers, each bearing the manufacturer's guaranteed analysis.

B. FERTILIZER:

1. Fertilizer shall be a complete, standard commercial fertilizer, homogeneous and uniform in composition, dry and free-flowing, and shall be delivered to the site in the manufacturer's original sealed containers, each bearing the manufacturer's guaranteed analysis and marketed in compliance with State and Federal Laws. All fertilizer shall be used in accordance with the manufacturer's recommendations.
2. Fertilizer for tree, shrub and groundcover plantings shall contain all major plant nutrients and minor trace elements essential to sustain plant growth and shall have the following analysis:

Nitrogen (N)	Phosphorous (P)	Potassium (K)
10%	10%	10%

3. As approved by the Engineer, a slow release root contact fertilizer installed at the time of planting, may be used in place of the above, at the discretion of the Contractor.
- C. Organic Compost shall be a standard commercial product comprised of fully decomposed, 100 percent plant-derived, natural organic matter. Its composition shall furnish ample water holding capacity and cation exchange capacity for the retention of plant nutrients. Compost shall be free of sticks, stones, weed seeds, roots, mineral or other foreign matter and delivered air dry. It shall be free from excessive soluble salts, heavy metals, phytotoxic compounds, and/or substances harmful to plant growth and viability. Organic compost shall have an acidity range of 4.5 to 7.0 pH.
- D. Sphagnum Peat Moss shall be a standard commercial product. Its composition shall furnish ample water holding capacity and cation exchange capacity for the retention of plant nutrients. Peat moss shall be free of sticks, stones, weeds or weed seeds, roots, mineral or other foreign matter. It shall be free from toxic substances and/or compounds harmful to plant growth and viability. It shall be delivered air dry in standard bales and shall have an acidity range of 3.5 to 5.5 pH.
- E. Humus shall be natural humus, reed peat, or sedge peat. Its composition shall furnish ample water holding capacity and cation exchange capacity for the retention of plant nutrients. Humus shall be free of sticks, stones, weeds, roots, mineral or other foreign matter and/or toxic substances harmful to plant growth and viability. It shall be low in wood content, free from hard lumps and excessive amounts of zinc and delivered air dry in a shredded or granular form. The acidity range for humus shall be 5.5 to 7.5 pH, and the organic matter content shall be not less than 85 percent, as determined by loss on ignition. The minimum water holding capacity shall be 200 percent by weight on an oven-dry basis.

- F. Manure shall be well-rotted, leached, cow manure not less than 8 months or more than 2 years old. It shall be free of sawdust, shavings, or refuse of any kind and shall not contain more than 25 percent straw. It shall contain no substances harmful to plant growth. The Contractor shall furnish information regarding chemical disinfectants, if any, that may have been used in storage of the manure.

2.3 PLANTING MIXTURE

Planting mix shall consist of 7 parts loam borrow and 1 part organic compost, humus, sphagnum peat moss, or manure, thoroughly blended.

2.4 WATER

Water shall be furnished by the Contractor, unless otherwise specified, and shall be suitable for irrigation and free from ingredients harmful to plant growth and viability. The delivery and distribution equipment required for the application of water shall be furnished by the Contractor, at no additional cost to the Owner.

2.5 MULCH

Mulch shall be fibrous pliable shredded soft bark mulch, not exceeding ½-inch in width. It shall be 98 percent organic matter with a pH range between 3.5 and 4.5 and a moisture content not to exceed 35 percent. It shall be free of weeds, weed seeds, debris, and other materials harmful to plant growth and viability. Organic mulch shall be aged no longer than 2 years.

2.6 MATERIALS FOR STAKING, GUYING, AND WRAPPING

- A. Tree stakes shall be sound, untreated 2 x 3 (nominal) x 8-foot length Douglas Fir reasonably free of knots. No paint or stain shall be used in conjunction with tree stakes. Tying material shall be flexible braided nylon webbing, ¾-inch wide and have a tensile strength of 900 pounds. Webbing shall be Green Tie Webbing by Agriculture Solutions LLC or approved equal.
- B. Drive anchors and guy wire assemblies shall be suitable for protecting trees and shall be sized in accordance with the manufacturer's recommendations. No materials shall be used for guying that will girdle, chafe, or otherwise injure trees.
- C. Tree wrap shall be duplex, waterproof kraft paper crinkled to 33-1/3 percent stretch, 4 to 6-inch wide strips. Tying materials shall be jute twine, 2-ply for shrubs and trees less than 3-inch caliper; 3-ply for larger plants.

2.7 TREE PAINT

Tree paint shall not be used.

2.8 ANTI-TRANSPIRANT/ANTI-DESICCANT

Anti-transpirant or anti-desiccant shall be 'Wilt-Pruf', as manufactured by Wilt-Pruf Products or approved equal. It shall be delivered in original sealed manufacturer's containers and used in accordance with the manufacturer's instructions.

2.9 INSECTICIDES

- A. No insecticides shall be used on-site without the Contractor notifying and obtaining the prior approval of the Engineer.
- B. Insecticides shall be EPA registered and approved for use in public open spaces. All insecticides shall be handled by State licensed applicators only, delivered in the original sealed manufacturer's containers, and used in accordance with the manufacturer's instructions.
- C. Insecticide use shall be limited and selective, only to control specific insect infestations, as identified by the Contractor or the Owner's Representative that may result in the disfigurement, decline, or death of plant materials.

2.10 HERBICIDES

- A. No herbicides shall be used on-site without the Contractor notifying and obtaining prior approval of the Engineer.
- B. Herbicides shall be EPA registered and approved for use in public open spaces. All herbicide shall be handled by State licensed applicators only, delivered in the original sealed manufacturer's containers, and used in accordance with the manufacturer's instructions.
- C. Herbicide for post-emergent application shall be Plateau by BASF, Snapshot 25 TG by Cortera Agriscience, or approved equal.
- D. Herbicide use shall be limited and selective, only to control specific weed infestations that have been identified by the Contractor or the Owner's Representative.

2.11 FUNGICIDES

- A. No fungicides shall be used on-site without the Contractor notifying and obtaining prior approval of the Engineer.
- B. Fungicides shall be EPA registered and approved for use in public open spaces. All fungicides shall be handled by State licensed applicators only, delivered in the original sealed manufacturer's containers, and used in accordance with the manufacturer's instructions.
- C. Fungicide use shall be limited and selective, only to control specific fungal pathogenic disease infestations, as identified by the Contractor or the Owner's Representative, that may result in the disfigurement, decline, or death of plant materials.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. All plants shall be subject to inspection and approval by the Engineer upon delivery to the site. No materials shall be planted until approval is received.
- B. All work shall be performed by skilled workers with a minimum of 2 years planting experience, in accordance with accepted horticultural/nursery practices, under the full-time supervision of a Certified Nurseryman or Arborist.

- C. All balled and burlapped plants that cannot be planted immediately upon delivery shall be set on the ground and the root balls shall be well protected with soil, wet moss, or other acceptable material. All foliage shall be protected and covered with perforated shade materials.
- D. The planting season for evergreen trees and shrubs shall extend from the time the soil becomes workable in the spring until new growth appears, and from September 15 until November 30 in the fall. Deciduous trees and shrubs shall be planted only when dormant, either prior to bud break and/or before leaves appear in the spring, or subsequent to their leaf drop in the fall. Ground covers shall be planted only after the last frost in the spring through mid-May. Planting season periods may be extended if weather and soil conditions permit only with the written approval of the Engineer. Extended or out-of-season planting requirements shall include application of antitranspirant and extra water as needed. Plant guarantee periods shall remain as stated below. Planting shall not be permitted in frozen ground.
- E. All plant locations and outlines for planting beds shall be staked out for review and potential adjustment by the Engineer before any excavation is begun. In the event that rock, underground construction work or obstructions are encountered in any proposed planting pit or bed, the Engineer may select alternate locations. Where locations cannot be changed, the obstruction shall be removed, subject to the Engineer's approval, to a depth of not less than 3 feet below grade and not less than 6-inches below the bottom of the root ball when plant is properly set at the required grade. Removal of boulders or obstructions greater than 1 cubic yard in size shall be subject to approval and will be paid for by the Owner. No ledge will be removed to create planting pits or beds
- F. All planting pits shall be excavated with sloped walls, wider at the top than at the bottom, and scarified to eliminate glazing. Tree pits shall be at least 2 feet greater in diameter than the root ball of earth or root system. Shrub pits shall be at least 1 foot greater than the diameter of the root ball. Planting pits shall not be deeper than the height of the root ball.
- G. When excavation occurs in areas of heavily compacted earth, stones, concrete chunks or other foreign matter, pits shall be dug at least 3 times the width of the root ball. Excavated material from plant pits shall be disposed of as required.
- H. Container plants shall be removed from their growing container before planting. If roots are densely matted, the outer root mass shall be scored, sliced vertically, with a sharp knife to separate roots. All herbaceous plants and groundcovers shall be evenly spaced to produce a uniform effect and staggered in rows at intervals designated on the contract drawings.
- I. Shrubs and trees shall be set in the center of planting pits, plumb and straight, and at such a level that after settlement the crown of the roots will be 1-inch above the surrounding finished grade. Root ball masses shall not be loosened, broken or damaged. When balled and burlapped plants are set, planting mixture shall be compacted around bases of balls to fill all voids. All tying materials, twine and rope shall be cut and removed. Biodegradable burlap shall be laid back or cut away from the top half of the ball. If a wire basket is present, the upper 2/3 of the basket shall be cut away and removed. Do not remove the entire basket. Roots or bare root plants shall be properly spread out and planting mixture carefully worked in among them. Broken or frayed roots shall be cleanly cut.
- J. Backfill plant pits with planting mixture in layers of not more than 9-inches and firmly tamp each layer and water to sufficiently settle the backfilled soil before the next layer

is put in place. When the planting pit is 2/3 backfilled, the hole shall be flooded and watered thoroughly so that the water level reaches the top of the planting pit. Allow water to soak in, then complete the backfilling operation. Immediately after planting pit is backfilled, a shallow basin 3-inches deep and slightly larger than the pit shall be formed with a ridge of soil for water retention. Form a common basin for plant materials throughout mass planting beds. After planting, lightly till the soil in planting beds between planting pits and rake smooth to eliminate compaction of soils.

- K. All planting hole basins shall be flooded with water twice within the first 24 hours of planting, and watered not less than twice per week until final acceptance of the work.
- L. All thin barked deciduous trees shall be wrapped after they are planted and before they are staked. Prior to wrapping, inspect trees for injury to trunks or improper pruning. Take corrective measures as necessary. Wrap trunks of all trees spirally from bottom to top with tree wrap and secure top and bottom at 2-foot intervals with jute twine. The wrapping shall overlap and entirely cover the trunk from the ground to the height of the second branches and shall be neat and snug. Overlap shall be approximately 2-inches.
- M. Stake trees immediately after planting as detailed. All staking apparatus shall be adequate to hold the tree in a vertical position under severe weather conditions. All staking apparatus and tree trunk wrapping shall be removed and disposed of off-site by the Contractor at the end of one growing season.
- N. Immediately after planting and staking operations are complete, all plant pit basins and plant beds shall be covered with approved mulch to the depths designated on the plans. Mulch shall not contact tree bark, cover tree root flares, or shrub crowns. No mulch shall be applied prior to the first watering.
- O. The pruning of trees and shrubs shall only be permitted to remove dead or dying branch limbs and tips, sucker growth, water sprouts, crossing or rubbing branches, broken or damaged branches, diseased or insect infested limbs, and to preserve the natural character of the plant. Plant materials shall be pruned in accordance with AmericanHort Standards and as required by the Engineer. Questionable weak limbs and branch removals that may disfigure the plant shall be left to the discretion of the Engineer. The tree leader shall never be permitted to be cut. Pruning shall be done with clean, sharp tools. All large pruning cuts that are 1/2-inch in diameter or larger shall be made along the bark branch ridge. Pruning cuts shall not breach or otherwise interfere with the branch collar. All pruning cuts less than 1/4-inch diameter shall be made with hand pruners as close to the main stem as possible without damaging the cambium or bud. Tree paint shall not be used to cover pruning cuts.
- P. As the work proceeds, the Contractor shall remove all debris from the site, including but not limited to branches, rock, paper, and rubbish. All areas shall be kept clean, neat and in an orderly condition at all times. Prior to final acceptance, the Contractor shall cleanup the entire area to the satisfaction of the Engineer.

3.2 MAINTENANCE

- A. Maintenance shall begin immediately after each plant is planted and shall continue until completion of the guarantee period and final acceptance of the project. Plants shall be watered, pruned, sprayed, fertilized, cultivated and otherwise maintained and protected. Tree guys and stakes shall be tightened and repaired. Defective work shall be corrected as soon as possible after it becomes apparent and weather and season permit.

- B. Settled plants shall be reset to proper grade and position, planting pits and common basins restored, and dead materials removed and replaced. Planting beds and individual basins shall be neat in appearance, maintained to their original layout lines and kept free of weeds. Mulch shall be replaced as required to maintain proper depths.
- C. Contractor shall make arrangements to provide sufficient water to maintain all trees, shrubs and plant materials until final acceptance. Plants shall be sprayed with anti-transpirant or anti-desiccant if required by seasonal conditions or as required by the Engineer.
- D. Planting areas shall be protected against trespass and damage of any kind during the maintenance period. This shall include the furnishing and installation of approved temporary fencing if necessary. If any plants become damaged during the maintenance period, they shall be treated or replaced as required by the Engineer at no additional cost to the Owner.

3.3 INSPECTION AND PRELIMINARY ACCEPTANCE

- A. Contractor shall provide written notice to the Engineer not less than 10 days before the anticipated date of inspection for preliminary acceptance. The Engineer shall recommend preliminary acceptance of the work of this Section only after completion and re-inspection of all necessary repairs, renewals or replacements.
- B. Inspection and acceptance of plantings may be requested and granted in part, provided the areas for which acceptance is requested are relatively substantial in size, and with clearly definable boundaries. Acceptance and use of these areas by the Owner shall not waive any other provisions of this Contract.

3.4 GUARANTEE

- A. All plant materials shall be guaranteed for a period of one year after the date of completion of the specified maintenance period and preliminary acceptance of the project by the Owner.
- B. When the work is accepted in part, the guarantee period shall extend from each partial acceptance to the terminal date of the last guarantee period. All guarantee periods terminate at one time.
- C. Plants shall be healthy, free of pests and disease. Plants shall exhibit vigorous growth, shall bear foliage of normal density, size and color and shall have no less than seventy-five percent (75%) of their branches alive at the end of the guarantee period. If the leader of any single-leader species is dead, the entire plant shall be considered dead.
- D. Any plant required under this Contract that is dead or unsatisfactory, as determined by the Engineer, shall be removed from the site. These shall be replaced as soon as weather permits during the specified planting season, at no additional cost to the Owner, until the plants live through one year.
- E. All replacements shall be plants of the same kind and size as specified on the Plant List. They shall be furnished and planted as specified above.
- F. The guarantee of all replacement plants shall extend for an additional one-year period from the date of their acceptance as replacement.

- G. Guarantee shall not apply to the replacement of unacceptable plants resulting from the removal, loss, or damage due to occupancy of the project in any part; vandalism or acts of neglect on the part of others; physical damage by animals, vehicles, etc.; and Acts of God, including but not limited to, catastrophic fire, hurricanes, riots, war, etc.
- H. In the instance of curtailment of water by local water authorities (when supply was to be furnished by the Owner), the Contractor shall furnish all necessary water by water tanker, the cost of which will be approved and paid for by the Owner.

3.5 FINAL INSPECTION AND FINAL ACCEPTANCE

- A. At the end of the guarantee period, the Contractor shall provide written notice to the Engineer not less than 10 days before the anticipated date of final inspection for final acceptance.
- B. The Engineer shall recommend final acceptance of the work of this Section only after completion and re-inspection of all necessary repairs, renewals or replacements.

END OF SECTION

SECTION 33 05 26.13

TRACER TAPE

PART 1 - GENERAL

1.1 WORK INCLUDED:

This section covers the furnishing, handling and installation of tracer tape, as called for on the drawings.

1.2 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 00 SUBMITTAL PROCEDURES, SUBMIT THE FOLLOWING:

- A. Manufacturer's literature on the materials, colors and printing specified herein, shall be submitted to the Engineer for review.
- B. Tape samples shall also be submitted to the Engineer for review.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS:

Tracer tape shall be by Reef Industries, Houston, TX; Empire Level, Mukwonago, WI; Pro-Line Safety Products Co., W. Chicago, IL; or approved equal.

2.2 TRACER TAPE:

- A. Tracer tape shall be at least 3-inches wide.
- B. Tracer tape for non-ferrous pipe or conduit shall be constructed of a metallic core bonded to plastic layers. The metallic tracer tape shall be a minimum 5-mil thick and must be locatable at a depth of 18-inches with ordinary pipe locaters.
- C. Tracer tape for ferrous pipe or conduit shall consist of multiple bonded plastic layers. The non-metallic tracer tape shall elongate at least 500% before breaking.
- D. The tape shall bear the wording: "BURIED DRAIN LINE BELOW" (with "DRAIN" replaced by "WATER", "SEWER", "ELECTRICAL", "GAS", "TELEPHONE", or "CHEMICAL" as appropriate), continuously repeated every 30-inches to identify the pipe.

Tape colors shall be as follows, as recommended by the American Public Works Association (APWA):

Electric	Red
Gas & Oil	Yellow
Communications	Orange
Water	Blue
Sewer & Drain	Green

PART 3 - EXECUTION

3.1 INSTALLATION:

- A. Tracer tape shall be installed directly above the pipe or conduit it is to identify, approximately 12-inches below the proposed ground surface.
- B. The Contractor shall follow the manufacturer's recommendations for installation of the tape, as approved by the Engineer.

END OF SECTION

SECTION 33 11 13.13

DUCTILE IRON PIPE AND FITTINGS FOR WATER MAINS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This Section covers the furnishing, handling, hauling, laying, jointing, testing and disinfecting of all ductile iron pipe, including fittings and appurtenant work as indicated on the drawings and as specified.
- B. Work shall be performed in accordance with the City of Worcester Department of Public Works & Parks Standard Construction Specifications and Details. Should there be discrepancies between Section 33 11 13.13 and the City's Specifications and Details, the latter shall govern.

1.2 RELATED WORK

- A. Section 31 00 00, EARTHWORK
- B. Section 33 11 13.13, WATER SERVICE CONNECTIONS
- C. Section 33 11 13.16, CONNECTIONS TO EXISTING WATER MAINS
- D. Section 33 12 22, HYDRANTS AND VALVES

1.3 QUALITY ASSURANCE

- A. All pipe and fittings shall be inspected and tested at the foundry as required by the standard specifications to which the material is manufactured. The Contractor shall furnish in duplicate to the Engineer sworn certificates of such tests.
- B. In addition, the Owner reserves the right to have any or all pipe, fittings and special castings inspected and/or tested by an independent service at either the manufacturer's plant or elsewhere. Such inspection and/or tests shall be at the Owner's expense.

1.4 REFERENCES

- A. The following standards, latest version thereof, form a part of this specification as referenced:

American Water Works Association (AWWA)

AWWA	C104	Cement-Mortar Lining for Ductile- Iron Pipe and Fittings
AWWA	C105	Polyethylene Encasement for Ductile Iron Pipe Systems
AWWA	C110	Ductile-Iron and Gray-Iron Fittings Water
AWWA	C111	Rubber Gasket Joints for Ductile- Iron Pressure Pipe and Fittings

AWWA	C116	Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings
AWWA	C150	Thickness Design of Ductile-Iron Pipe
AWWA	C151	Ductile-Iron Pipe, Centrifugally Cast for Water
AWWA	C153	Ductile-Iron Compact Fitting for Water Service.
AWWA	C600	Installation of Ductile-Iron Water Mains & Their Appurtenances
AWWA	C651	Disinfecting Water Mains

1.5 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 00 SUBMITTAL PROCEDURES, SUBMIT THE FOLLOWING:

- A. Shop drawings shall be submitted to the Engineer for review.
- B. Shop drawings shall consist of manufacturer's scale drawings, cuts or catalogs including descriptive literature and complete characteristics and specifications, and code requirements. Shop drawings shall be submitted for the ductile iron pipe, type of joint, fittings, couplings, filling rings, restrained joints, and lining and coating in accordance with specifications.

PART 2 - PRODUCTS

2.1 PIPE:

- A. The Contractor shall use push-on joint type ductile iron pipe unless otherwise indicated on the plans or specified herein.
- B. All ductile iron pipe shall be designed in accordance with AWWA C150 and shall be manufactured in accordance with AWWA C151.
- C. Unless otherwise indicated or specified, ductile iron pipe shall be Thickness Class 52.

2.2 JOINTS:

- A. Joints for ductile iron pipe shall conform to AWWA C111.
- B. Pipe and fittings shall be furnished with approved joint restraining appurtenances as specified herein, or within the limits as indicated on the drawings, to keep the piping from pulling apart under pressure.

2.3 FITTINGS:

- A. Fittings shall conform to the requirements of AWWA C110 or C153 as appropriate and shall be of a pressure classification at least equal to that of the pipe with which they are used.
- B. The Contractor shall use ductile iron fittings. Cast-iron, Class 250 fittings may be substituted, upon approval of the Engineer, for ductile iron fittings.

- C. Unless otherwise indicated, fittings shall have all bell mechanical joint ends.

2.4 GASKETS, GLANDS, NUTS AND BOLTS:

- A. Gaskets, glands, nuts, bolts and accessories shall conform to AWWA C111 or C153 as appropriate.
- B. Gaskets shall be of plain tipped rubber, suitable for exposure to the liquid within the pipe.
- C. Glands shall be ductile or cast iron.
- D. Bolts and nuts shall be high strength alloy.

2.5 LINING AND COATING:

- A. The inside of pipe and fittings shall be given a cement lining and asphaltic seal coat in accordance with AWWA C104. The thickness of the lining shall be double that specified in AWWA C104.
- B. The outside of pipe and fittings shall be coated with the standard asphaltic coating specified under the appropriate AWWA Standard Specification for pipe and fittings.
- C. Machined surfaces shall be cleaned and coated with a suitable rust preventative coating at the shop immediately after being machined.

2.6 FLEXIBLE COUPLINGS:

- A. The Contractor shall use solid sleeve coupling fittings for joining pipe. With the approval of the Engineer, sleeve-type flexible couplings may be substituted.
- B. All sleeve-type couplings and accessories shall be of a pressure rating at least equal to that of the pipeline in which they are to be installed.
- C. Couplings shall be cast or ductile iron and shall be provided with gaskets of a composition suitable for exposure to the liquid within the pipe.
- D. Sleeve-type couplings shall be made by Dresser, Bradford, PA; Smith-Blair (a Xylem brand), Texarkana, Arkansas; Romac Industries Inc., Seattle, WA; Ford Meter Box Co., Wabash, IN; or be an approved equal.
- E. Couplings for buried pipe shall be Dresser 138 or 38; Smith-Blair Type 441; Romac Style 501; Ford Style FC1 or FC2W; or approved equal.

2.7 JOINT RESTRAINTS:

- A. Where indicated or necessary to prevent joints or sleeve couplings from pulling apart under pressure, anchoring and joint restraint methods shall be utilized. Methods shall be restrained joint systems. The number of joints to be restrained shall be determined in accordance with Table 1, as shown on the construction plans or provided by the Engineer.
- B. Restrained joint systems for standard mechanical joint fittings or push on joint pipe shall be restraining glands (Megalug by EBAA Iron Sales Inc., Eastland, TX; StarGrip by Star Pipe Products, Houston, TX; RomaGrip by Romac Industries, Inc., Seattle, WA; Sigma One-Lok by Sigma Corporation, Cream Ridge, NJ; or approved equal) and restraining gaskets (Fast-grip by American Cast Iron Pipe Company, Birmingham,

AL; Field Lok 350 Gasket by United States Pipe and Foundry Company, Birmingham, AL; Sure Stop 350 Restrained Joint Gaskets by McWane Ductile, Phillipsburg, NJ; or approved equal). Methods that rely on the use of friction clamps and/or retainer glands with set screws alone are not acceptable.

- C. Restrained joint systems for non-standard or modified joints shall be Flex-Ring or Lok-Ring by American Cast Iron Pipe Company, Birmingham, AL; TR Flex Joint by McWane Ductile, Phillipsburg, NJ; TR-Flex Joint by United States Pipe and Foundry Company, Birmingham, AL; Snap-Lok or Bolt-Lok by United States Pipe and Foundry Company, Birmingham, AL; or approved equal.
- D. Concrete thrust blocks may only be used for 6-inch, 8-inch, 10-inch, or 12-inch pipe where use of a joint restraint system is not feasible. Use of concrete thrust blocks shall be installed with the minimum bearing area (in square feet) against undisturbed material in accordance with the following:

Size of Main	90° Bends, Tees, Caps and Plugs	45° Bends and Wyes	22-½° Bends	11-¼° Bends
6- & 8-inch	5	4	2	2
10- & 12-inch	12	9	5	2

- E. Tie rods may only be used for 6-inch, 8-inch, 10-inch, or 12-inch pipe where use of a joint restraint system is not feasible. Bolts shall have adequate length to allow nuts on both sides of the gland. Tie bolts shall have the same diameter as the tie rods and be in accordance with the following:

Pipe Size	Tie Rod	
	Number	Diameter
6	2	½"
8	2	¾"
10	2	¾"
12	4	¾"

- F. Location of restrained joints shall be based on Table 1, as shown on the construction plans or provided by the Engineer. All joints that occur within the restrained length listed in Table 1, for the specific application, shall be restrained. For example, for a 90° bend, 8-inch unwrapped pipe, the restrained length required is 33 feet. Therefore, all joints within 33 feet of the 90° bend must be restrained.

2.8 POLYETHYLENE ENCASEMENT:

- A. Where called for on the drawings, the pipe shall be encased in polyethylene conforming to AWWA C105.
- B. Polyethylene encasement shall be either linear low density, minimum 8 mils thick or high density, cross-laminated, minimum 4 mils thick. Polyethylene encasement shall be clearly marked at a minimum of every 2-feet along its length with print that does not contain hazardous material. Markings shall contain manufacturer's name, manufacture year, AWWA C105, minimum film thickness, and 'Warning - Corrosion Protection - Repair any damage.'

- C. Adhesive tape shall be dielectric tape, suitable for use with polyethylene encasement. The use of duct tape shall not be accepted.

PART 3 - EXECUTION

3.1 INSPECTION BEFORE INSTALLATION:

Pipes and fittings shall be subjected to a careful inspection just before being laid or installed.

3.2 HANDLING AND CUTTING:

- A. Any pipe or fitting which has a damaged lining, scratched or marred machine surface and/or abrasion of the pipe coating or lining shall be rejected and removed from the job-site.
- B. Any fitting showing a crack and any fitting or pipe which has received a severe blow that may have caused incipient fracture, even though no such fracture can be seen, shall be marked as rejected and removed at once from the work.
- C. In any pipe showing a distinct crack and in which it is believed there is no incipient fracture beyond the limits of the visible crack, the cracked portions, if so approved, may be cut off by and at the expense of the Contractor before the pipe is laid so that the pipe used will be perfectly sound. The cut shall be made in the sound barrel at a point at least 12-inches from the visible limits of the crack.
- D. Except as otherwise approved, all cutting shall be done with a machine suitable for cutting ductile iron pipe. Hydraulic squeeze cutters are not acceptable for cutting ductile iron pipe. Travel type cutters or rotary type abrasive saws may be used. All cut ends shall be examined for possible cracks caused by cutting.
- E. Lined and coated pipe and fittings shall be assembled and installed with approved packing or gaskets of the type recommended by the pipe manufacturer for the particular lining used.

3.3 INSTALLATION:

- A. DEPTH:
 - 1. The pipe shall be installed with a minimum of 5'-0" of cover, unless specifically indicated otherwise on the plans or required by the Engineer.
- B. PIPE AND FITTINGS:
 - 1. No defective pipe or fittings shall be laid or placed in the piping, and any piece discovered to be defective after having been laid or placed shall be removed and replaced by a sound and satisfactory piece.
 - 2. Each pipe and fitting shall be cleared of all debris, dirt, etc., before being laid and shall be kept clean until accepted in the complete work.
 - 3. Pipe and fittings shall be laid accurately to the lines and grades indicated on the drawings or as required. Care shall be taken to ensure good alignment both horizontally and vertically.
 - 4. In buried pipelines, each pipe shall have firm bearing along its entire length.

5. Castings to be encased in masonry shall be accurately set, with the bolt holes, if any, carefully aligned.
6. Immediately prior to being set, castings shall be thoroughly cleaned of all rust, scale and other foreign material.
7. Fittings shall not be used to clear beneath or above an existing structure or pipeline unless approved by the Engineer. The water main shall be brought to a depth sufficient to clear the structure or pipeline without the use of bends.

C. TEMPORARY PLUGS:

1. At all times when pipe laying is not actually in progress, the open ends of pipe shall be closed by temporary watertight plugs or by other approved means. If water is in the trench when work is resumed, the plug shall not be removed until all danger of water entering the pipe has passed.

D. PUSH ON JOINTS:

1. Joining of push-on joint pipe shall conform to AWWA C600.
2. If effective sealing of the joint is not attained, the joint shall be disassembled, thoroughly cleaned, a new gasket inserted and joint reassembled.
3. Deflection of alignment at a joint shall not exceed the appropriate permissible deflection as specified in AWWA C600. The tables in AWWA C600 indicate the maximum permissible deflection for 18 and 20-foot pipe lengths. Maximum permissible deflections for other lengths shall be in proportion to such lengths.

E. MECHANICAL JOINTS:

1. Assembling of fittings with mechanical joint ends shall conform to AWWA C600.
2. If effective sealing of the joint is not attained at the maximum torque indicated in the above standard, the joint shall be disassembled and thoroughly cleaned, then reassembled. Bolts shall not be overstressed to tighten a leaking joint.
3. The deflection of alignment at a joint shall not exceed the appropriate permissible deflection as specified in the following table. These values indicate the maximum permissible deflection for 18-foot lengths. Maximum permissible deflections for other lengths shall be in proportion to such lengths.

Pipe Deflection Allowances
Maximum permissible deflection, inches

<u>Diameter of Pipe (inches)</u>	<u>Mechanical-Joint</u>
6	27
8-12	20
16	13.5
20	11
24	9

F. RESTRAINED JOINTS:

1. Joining of restrained joint piping shall conform to the manufacturer's recommendations.
2. If effective sealing of the joint is not attained, the joint shall be disassembled, thoroughly cleaned, a new gasket inserted and joint reassembled.
3. Deflection of alignment at a joint shall not exceed the appropriate permissible deflection recommended by the manufacturer.
4. All restraining appurtenances (and tie rods) shall be coated with an approved bituminous paint after assembly. The completed joint shall be inspected and the paint repaired/touched-up as necessary.

G. SLEEVE-TYPE COUPLINGS:

1. Pipe ends shall be cleaned thoroughly prior to installation. After the bolts have been inserted and all nuts have been made up finger tight, diametrically opposite nuts shall be progressively and uniformly tightened all around the joint, preferable by use of a torque wrench of the appropriate size and torque for the bolts. The correct torque as indicated by a torque wrench shall not exceed 90 foot-lb. for joints up to 24-inches.

3.4 POLYETHYLENE ENCASEMENT:

- A. The pipe to be encased shall be thoroughly cleaned of all soil and debris prior to installation of the polyethylene encasement. No soil or debris shall be allowed to enter the encasement during or after its installation.
- B. Polyethylene encasement shall be installed using Method A as described in AWWA C105, with the encasement joints coincident with pipe joints. Adhesive tape shall be used to secure the encasement.
- C. Minimum overlap of polyethylene encasement shall be 24-inches, 12 inches on each side of pipe joints.
- D. If required, two layers of polyethylene encasement shall be installed. The first layer shall be completely installed on and secured to the length of pipe before the second layer is installed.

- E. Tears, cuts and other damage shall be repaired with a piece of polyethylene covering secured with adhesive tape, when approved by the Engineer. Otherwise, the damaged length of polyethylene shall be replaced at the Contractor's expense.
- F. Care shall be taken when backfilling to avoid damage to the polyethylene encasement.
- G. Service and fitting connections shall be made by making an x-shaped cut in the polyethylene and folding back the cut film. Immediately following completion of the connection, the film shall be secured to the connection with adhesive tape and the cut area repaired. Service connections shall be wrapped with polyethylene encasement for a minimum of 3 feet from the point of connection to the encased pipe.
- H. At the junctions between wrapped and unwrapped pipe the polyethylene encasement shall be extended a minimum of 3 feet beyond the end of the pipe scheduled to be encased and the ends of the encasement securely taped so that no soil can enter the encasement.

3.5 TESTING:

- A. Prior to the hydrostatic pressure test, the piping shall be thoroughly flushed clean of all dirt, dust, oil, grease and other foreign material. This work shall be done with care to avoid damage to linings and coatings. Flushing velocity shall be a minimum of 2.5 ft. /sec.
- B. The installed pipe shall be pressure tested in accordance with AWWA Standard C600.
- C. HYDROSTATIC PRESSURE TEST:
 - 1. Unless otherwise approved, all pipelines shall be given a hydrostatic pressure test between line valves. The Contractor shall furnish and install suitable temporary testing plugs or caps; all necessary pressure pumps, pipe connections, meters, gates, and other necessary equipment; and all labor required. The Owner or Engineer shall have the privilege of using its own gauges.
 - 2. Subject to approval and provided that the tests are made within a reasonable time considering the progress of the project as a whole, and the need to put the section into service, the Contractor may make the tests when desired.
 - 3. Pipelines intended for buried service shall be tested after backfill and compaction of the trench.
 - 4. The section of pipe to be tested shall be filled with water of approved quality and all air shall be expelled from the pipe. The Contractor shall follow established procedures for filling the pipe and expelling trapped air to avoid exposing the piping system to water-hammer. If blowoffs are not available at high points for releasing air, the Contractor shall excavate as required and install the necessary taps. If the Contractor changes the grade of pipe installation, it will be responsible for locating the taps at the correct location in the system for testing. Taps shall be installed at the beginning and end of each disinfection run. After completion of the test, if so required by the Engineer, the Contractor shall remove corporations used for testing; plug the holes; and backfill, as necessary.

5. The section under test shall be maintained full of water at working pressure for a period of 24 hours prior to the hydrostatic pressure test being applied to stabilize the pipeline with respect to movement under pressure, water absorption by the lining, etc. The pipeline may require several cycles of pressurizing and bleeding trapped air prior to beginning the test.
6. When hydrants are in the pipeline test section, the hydrostatic test shall be made against the main valve in the hydrant. The hydrostatic test shall not be conducted against the branch valve.
7. The hydrostatic test shall consist of raising the water pressure within the test section to a pressure not less than 1.25 times the working pressure of the pipeline measured at the highest elevation along the test section and not less than 1.5 times the working pressure of the lowest elevation of the test section. The specified test pressure shall be corrected to the elevation of the test gauge.
8. The hydrostatic test shall be of at least a 2 hour duration. The test pressure shall not vary by more than +/- 5 psi for the duration of the test. Test pressure shall be maintained within this tolerance by adding makeup water through the pressure test pump into the pipeline test section.
9. The amount of makeup water (testing allowance) added to the test section shall be accurately measured by suitable methods and shall not exceed the maximum allowable quantity of makeup water. No pipe installation will be accepted if the quantity of makeup water is greater than that determined by the following formula:

$$L = \frac{S D \sqrt{P}}{148,000}$$

Where:

- L = makeup water, in gallons per hour
- S = length of test section, in feet
- D = nominal diameter of pipe, in inches
- P = average test pressure, in psi (gauge)

10. If the section fails to pass the hydrostatic pressure test, the Contractor shall do everything necessary to locate, uncover, and repair or replace the defective pipe, fitting, or joint, all at its own expense and without extension of time for completion of the work. Additional tests and repairs shall be made until the section passes the specified hydrostatic test.

3.6 DISINFECTION AND FLUSHING:

- A. The Contractor shall disinfect the lines carrying potable water.
- B. The Contractor shall furnish all equipment and materials necessary to do the work of disinfecting and shall perform the work in accordance with the procedure outlined in AWWA C651 and all amendments thereto.
- C. In general, the procedure of disinfecting the main shall be to apply the chlorine through a tap in one end of the section and bleed it off through a tap at the other end.
- D. The applied dosage shall be such as to produce a chlorine concentration of not less than 10 mg/l after a contact time of not less than 24 hours.

- E. During the disinfection period, care shall be exercised to prevent contamination of water in existing mains.
- F. Any temporary connection to the mains or other facilities required to accomplish the disinfection of the mains shall be at the Contractor's expense.
- G. After treatment, the main shall be flushed with clean water until the residual chlorine concentration is less than 0.2 mg/l. The flushing rate shall be 3.0 ft/sec to achieve full scour of sand particles.
- H. Before disposing of the water used in disinfecting and flushing water mains the Contractor shall thoroughly neutralize it through the application of a reducing agent, as referenced in AWWA C651 and C655.
- I. Bacteriological sampling and testing shall be done in accordance with AWWA C651 (Option A – One sample taken after flushing is complete followed by another sample taken 16 hours after the first sample or Option B – Two samples taken 15 minutes apart after a 16 hour post flushing rest period) for each main and each branch. Sampling shall be accomplished with sterile bottles treated with sodium thiosulfate, as required by Standard Methods. No hose or fire hydrants shall be used in collection of samples. A corporation stop installed on the main, with a removable copper tube gooseneck assembly, is the recommended method.
- J. Bacteriological sampling and testing shall be conducted by a state-certified laboratory certified for total and fecal coliform analyses of potable water.
- K. Testing shall be done by a laboratory approved by the Engineer, in accordance with Standard Methods, and shall show the absence of coliform organisms. A standard plate count may be required at the option of the Engineer.

END OF SECTION

SECTION 33 11 13.34

CONNECTIONS TO EXISTING WATER MAINS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This section covers connections to existing water mains, complete.
- B. The Contractor shall furnish all pipe, fittings, valves, tapping machines, if required, and appurtenances. The Contractor shall do all excavation and backfill as required.
- C. Work shall be performed in accordance with the City of Worcester Department of Public Works & Parks Standard Construction Specifications and Details. Should there be discrepancies between Section 33 11 13.34 and the City's Specifications and Details, the latter shall govern.

1.2 RELATED WORK

- A. Section 03 05 00, FIELD CONCRETE
- B. Section 33 11 13.13, DUCTILE IRON PIPE AND FITTINGS
- C. Section 33 12 22, HYDRANTS AND VALVES. (Tapping sleeves and valves specified)

PART 2 - PRODUCTS: NOT APPLICABLE

PART 3 - EXECUTION

3.1 CONTRACTOR OPERATIONS

- A. The Contractor shall make all connections to the existing mains as indicated on the drawings and as herein specified.
- B. The Contractor shall develop a program for the construction and putting into service of the new work subject to the approval of the Engineer. All work involving cutting into and connecting to the existing work shall be planned so as to interfere with operation of the existing facilities for the shortest possible time and when the demands on the system best permit such interference even to the extent of working outside of normal working hours to meet these requirements.
- C. The Contractor shall have all possible preparatory work done prior to making the connection and shall provide all labor, tools, material, and equipment required to do the work in one continuous operation.
- D. The Contractor shall have no claim for additional compensation, by reason of delay or inconvenience, for adapting its operations to the needs of the Owner's water supply. No damages shall be claimed by the Contractor for delays in dewatering pipelines nor shall any damages be claimed because of water leaking through closed valves after dewatering is completed.

- E. Under no circumstances shall any customers be without water for a period of more than 4 hours without prior approval of the Owner. Should it appear that any customer will be without water for more than 4 hours, the Contractor shall install temporary water service where required by the Engineer.
- F. Existing pipeline that is not to be abandoned but is damaged by the Contractor during the work shall be replaced by it at its own expense in a manner approved by the Engineer.

3.2 TAPPING CONNECTION TO EXISTING MAINS

- A. Tapping connections to the existing mains, where indicated on the drawings, shall be made with service pressure in the main, using tapping sleeves and valves and a suitable tapping machine.
- B. Other connections to existing mains shall be made with the main out of service, unless otherwise required by the Engineer. Such connections will not require tapping sleeves and valves but connections as indicated on the drawings.

END OF SECTION

SECTION 33 12 22

HYDRANTS AND VALVES FOR POTABLE WATER WORK

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This Section covers the furnishing and installation of all outside hydrants, valves and appurtenances as indicated on the drawings and as specified herein.
- B. Pipe and couplings shall be specified under the appropriate pipe sections.
- C. Work shall be performed in accordance with the City of Worcester Department of Public Works & Parks Standard Construction Specifications and Details. Should there be discrepancies between Section 33 12 22 and the City's Specifications and Details, the latter shall govern.

1.2 RELATED WORK:

- A. Section 31 00 00, EARTHWORK
- B. Section 33 11 13.13, DUCTILE IRON PIPE AND FITTINGS FOR WATER MAINS
- C. Section 33 11 13.34, CONNECTIONS TO EXISTING WATER MAINS

1.3 REFERENCES:

- A. The following standards form a part of this specification:

ASTM International (ASTM)

ASTMA48		Standard Specification for Gray Iron Castings
ASTMA126		Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
ASTMA536		Standard Specification for Ductile Iron Castings
ASTM	B62	Standard Specification for Composition Bronze or Ounce Metal Castings
ASTM	D429	Standard Test Methods for Rubber Property-Adhesion to Rigid Substrates

American Water Works Association (AWWA)

AWWA	C500	Metal Seated Gate Valves For Water Supply Service
AWWA	C502	Dry-Barrel Fire Hydrants
AWWA	C504	Rubber-Seated Butterfly Valves

AWWA	C509	Resilient-Seated Gate Valves for Water-Supply Service
AWWA	C515	Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service
AWWA	C550	Protective Interior Coatings for Valves and Hydrants

1.4 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF THE GENERAL SPECIFICATIONS, SUBMIT THE FOLLOWING:

- A. Shop drawings shall be submitted for the hydrants, valves and appurtenances indicating type of joint, and lining and coating, etc., in accordance with the specifications.
- B. Shop drawings shall consist of manufacturer's scale drawings, cuts or catalogs including descriptive literature and complete characteristics and specifications, and code requirements.
- C. Refer to Paragraph 3.01.A for Affidavit of Compliance required to be submitted.

PART 2 - PRODUCTS

2.1 GENERAL:

- A. Valves shall open right (clockwise).
- B. Hydrants shall open right (clockwise).

2.2 HYDRANTS:

- A. Hydrants shall conform to the requirements of AWWA C502. They shall be equipped with a 5-1/4-inch main valve and 6-inch mechanical joint inlet.
- B. Hydrants shall be equipped with two (2) 2½ inch hose nozzles and one (1) 4½ inch pumper nozzle, national standard thread. Hose and pumper nozzles shall be the ¼ turn type, secured into the upper barrel of the hydrant by O-ring seals and stainless-steel retaining screws. Each nozzle cap shall be provided with a Buna N rubber washer.
- C. Hydrant operating and nozzle cap nuts shall be of pentagonal shape and measure one and one half inches from flat to point. The height of the nut shall not be less than one inch.
- D. All internal operating parts including main valve, main valve seat, drain valve mechanism, operating rod, etc., shall be removable without excavating.
- E. Main valve seat rings shall be made of brass or bronze and shall screw into a seat retainer ring or sub-seat, which shall also be made of brass or bronze.
- F. Hydrants shall be traffic models with frangible bolts or breakaway couplings. Details of hydrant design shall meet the requirements of the Owner.
- G. For purposes of standardization, hydrants shall be Kennedy Hydrant K81D, as manufactured by Kennedy Valve, Elmira, NY.

2.3 HYDRANT PAINT:

- A. Hydrants shall be thoroughly cleaned and given two shop or field coats of paint in accordance with AWWA C502 and the instructions of the paint manufacturer. Paint color shall be the standard hydrant color of the Owner as follows:
 - 1. Barrel - OSHA yellow
 - 2. Bonnet - OSHA yellow
 - 3. Nozzle Caps - OSHA yellow
- B. If the hydrants are delivered with the Owner's standard color, they shall be given one matching field coat of an alkyd gloss enamel. If the hydrants are not delivered with the Owner's standard color, they shall be given two coats of an alkyd gloss enamel, colors as indicated above.
- C. Hydrant paint shall be Insil-X, Al Pro; Wilbur Williams, Totrust; or Rust-O-Leum, High Performance Industrial.
- D. Alkyd gloss enamel shall be 801 DTM by Sherwin-Williams, Series 2H-Hi-Bold Tneme-Gloss by Tnemec; or approved equal. Reflective paint shall be by Pollardwater.

2.4 RESILIENT SEAT GATE VALVES:

- A. Resilient seat, wedge type gate valves shall be manufactured to meet all applicable requirements of AWWA C509 or AWWA C515. All valves shall be bubble-tight at 200 psi water working pressure, tested in both directions.
- B. Valve bodies shall be of cast or ductile iron and shall have non-rising threaded bronze stems acting through a bronze stem nut. Opening nuts shall be 2-inches square and shall open as specified above. All buried valves shall have mechanical joint ends.
- C. Valve wedges shall be of ductile iron with resilient seating surfaces permanently bonded to the wedges in strict accordance with ASTM D429 or attached to the face of the wedges with stainless steel screws. Each valve shall have a smooth, unobstructed water way free from sediment pockets.
- D. Valves shall have low friction, torque-reduction thrust bearings. All O-rings and gaskets shall be removable without taking the valves out of service.
- E. An NSF 61-approved epoxy coating, which is safe for potable water, shall be applied to exterior and interior valve surfaces.
- F. Valves for horizontal applications shall have Delrin wedge covers and be specifically designed for horizontal installation.
- G. Resilient seat gate valves shall be as manufactured by Clow Valve Co., Oskaloosa, IA; Mueller Co., Decatur, IL; American Valve and Hydrant; Beaumont, TX; MH Valve, Anniston, AL; Kennedy Valve, Elmira, NY; or approved equal.
- H. Post indicating valve assemblies shall have a post and indicator as an integral part of the resilient seated gate valve assembly. The unit shall be provided with a detachable crank which OPENS the valve in a counterclockwise direction. Shafts shall be Type 304 stainless steel. Post indicators and valves shall be UL listed; FM approved. Post indicators and valves shall be manufactured by Pratt, Clow or approved equal.

2.5 TAPPING SLEEVES AND VALVES:

- A. Tapping sleeves and valves shall consist of a split cast iron or ductile iron sleeve tee with mechanical joint ends on the main and a flange on the branch. Tapping-type

gate valves shall have one flange and one mechanical joint end. The valves shall conform to the requirements hereinbefore specified for gate valves and shall be furnished with a 2-inch square operating nut. The Contractor shall be responsible for verifying the outside diameter of the pipe to be tapped.

- B. Oversized valves shall be provided as required to permit the use of full size cutters. Before backfilling, all exposed portions of bolts used to hold the two halves of the sleeve together shall be heavily coated with two coats of bituminous paint comparable to Inertol No. 66, Special Heavy. Sleeves shall be of cast iron furnished with rubber gaskets. Gaskets shall cover the entire area of flange surfaces.
- C. Tapping sleeves and valves shall be as manufactured by Mueller Co., Decatur, IL; American Valve and Hydrant, Birmingham, AL; Kennedy Valve, Elmira, NY; US Pipe Valve & Hydrant, Chattanooga, TN; or approved equal.

2.6 BUTTERFLY VALVES:

- A. Buried butterfly valves shall be Class 150B, iron body, rubber seated, with mechanical joint ends. Butterfly valves shall conform to AWWA C504, except as otherwise specified herein. Butterfly valves shall have valve seats designed to provide bubble-tight shutoff at 150 psi upstream and downstream.
- B. Butterfly valve designs utilizing continuous lining on the internal body surfaces and extending over the flanges, will NOT be acceptable. Valve disks shall seat at an angle of 90 degrees to the axis of the pipe.
- C. Valve seats shall be of molded natural rubber, BUNA-NM or EPDM. Rubber seats may be attached to the body or the disk. If the seat is attached to the disk, the seat ring on the body shall be of stainless steel. Bolts shall extend through the seat.
- D. Seats mounted on the disk shall be securely clamped to the disk. All clamps, retaining rings, and their fasteners shall be Series 300 stainless steel.
- E. The valve disk shall be of either ductile iron conforming to ASTM A536 or Type 304 stainless steel.
- F. The valve shaft shall be Type 300 stainless steel or carbon steel with stainless steel joints. The valve disk and shaft connection shall be by means of mechanically secured taper pins extending through the disk and shaft. Taper pins, lock washers and nuts shall be 18-8 stainless steel. The shaft seals shall be designed for the use of standard chevron type packing or standard O-ring seals.
- G. The manual operation mechanism shall be firmly fixed to the valve body. The operator shall be permanently lubricated, and totally enclosed with a cast iron case, and the nut for buried valves shall turn in the direction specified above to open. The operator for buried valves shall be suitable for submersion. The operator shall have adjustable threaded collars at each end of the stroke.
- H. Butterfly valves shall be as manufactured by M&H Valve Company, Anniston, AL; Emerson Keystone, Houston, TX; Pratt a Mueller brand, Aurora, IL; or approved equal and shall conform to the above specifications.

2.7 WATER LINE STOPS:

- A. The water line stop fitting body shall consist of a ductile iron or ASTM A-36 steel fusion bonded epoxy coated to 10-12 mils in accordance with AWWA C-213. The fitting shall be full encirclement, pressure retention-type split tee. The outlet of the

fitting shall have locking pins built in to retain the completion plug. The contractor shall be responsible for verifying the outside diameter of the pipe where the valve will be inserted.

- B. Before backfilling, all exposed portions of bolts used to hold the two halves of the sleeve together shall be heavily coated with two coats of bituminous paint comparable to Inertol No. 66, Special Heavy. Sleeves shall be furnished with a nitrile gasket that fits 360 degrees around the pipe at each end.
- C. The completion plug shall be machined from a stress relieved carbon steel weldment. It shall contain two (2) circumferential grooves: one to receive the locking devices from line stop flange and second to contain a compressible "O" ring to seal tight under pressure. The line stop fitting shall be closed with a blind flange. Facing and drilling of the blind flange shall be compatible with that of the line stop flange.
- D. The Contractor shall provide the materials, machines, and related equipment necessary to install the line stop into an existing piping system under full operating pressure without interrupting service.
- E. Line stops shall be manufactured by South Shore Pipeline, Hanover MA, John Hoadley & Sons, Inc. Rockland MA, Hydra-Stop, Inc., Burr Ridge, IL; IPSCO Paulsboro NJ; or approved equal.

2.8 VALVE BOXES AND EXTENSIONS:

- A. Valve boxes shall be manufactured in North America. The minimum outside diameter of the boxes shall be 5½-inches and the lengths shall be as necessary to suit the ground elevation and the depth of each valve operator, regardless of the depth of cover.
- B. When there is more than 6 feet of cover, valve operators shall have non-rising extension stems which raise the operating nut to a depth of approximately 4 feet below grade. The extension stem shall have a centering support ring at the upper end. The lower socket shall be tapped with a set screw into the valve nut to prevent the extension stem from lifting off the valve nut.
- C. Each valve shall be provided with a box which has a close fitting 7-1/4-inch diameter cover and is substantially dirt-tight. The top of the cover shall be flush with the top of the box rim. The word "WATER" shall be cast in the top of the cover.
- D. Valve boxes shall be of cast iron and of the adjustable sliding, heavy pattern type. They shall be so designed and constructed as to prevent direct transmission of traffic loads to the pipe or valve. The upper or sliding section of the box shall be provided with a flange on the top of the section (not on the bottom) having sufficient bearing area to prevent undue settlement. The lower section of the box shall be designed to enclose the operating nut and stuffing box of the valve and to rest on the backfill. The boxes shall be adjustable through at least 6 inches vertically without reduction of lap between sections to less than 8-inches.

2.9 POLYETHYLENE ENCASEMENT:

Where called for on the drawings, the pipe shall be encased in polyethylene conforming to AWWA C105.

PART 3 - EXECUTION

3.1 AFFIDAVIT OF COMPLIANCE

- A. The manufacturer shall furnish as part of the shop drawing submittal the ENGINEER with an affidavit stating that valve(s), hydrants conform to the applicable requirements of the applicable AWWA Standard and the ENGINEER's specifications, and that all tests specified therein have been performed and all test requirements have been met and the test date.
- B. A copy of the Affidavit of Compliance shall be delivered to the construction site attached to each valve and/or hydrant furnished. The Affidavit shall be attached to the valve or hydrant inside a waterproof pouch.
- C. Any valve or hydrant received without the required affidavit shall be removed from the project and replaced at no expense to the Owner.
- D. All materials shall be certified "NEW." No reconditioned or repaired materials are permitted. Any reconditioned or repaired materials furnished or installed shall be removed and replaced with new materials at no expense to the Owner.

3.2 INSTALLATION:

- A. All valves shall be carefully installed and supported in their respective positions free from distortion and strain. Care shall be taken to prevent damage or injury to the valves and appurtenances during handling and installation.
- B. All material shall be carefully inspected for defects in workmanship and all debris and foreign material cleaned out of valve openings and seats. All mechanisms shall be operated to check for proper functioning, and all nuts and bolts checked for tightness.
- C. Valves and other equipment that do not operate easily or are otherwise defective shall be repaired or replaced at the Contractor's expense.
- D. Hydrants shall be set plumb. Earth fill shall be carefully tamped around the hydrants to a distance of 4 feet on all sides of the hydrant, or to the undisturbed trench face, if less than 4 feet. Hydrants and connecting pipe shall have at least the same depth of cover as the distributing main. Hydrants shall be set upon a layer of stone or a slab of concrete not less than 4 inches thick and 15 inches square. The side of the hydrant opposite the pipe connection shall be firmly wedged against the vertical face of the trench with a concrete thrust block, as indicated on the drawings.
- E. Broken stone shall be placed around the base of the hydrant at the location of the drain hole and backfill around the hydrant shall be thoroughly compacted to the grade line in a satisfactory manner. Hydrants shall have the interiors cleaned of all foreign matter before installation and shall be inspected in both the open and closed positions.
- F. The body of the hydrant shall be of sufficient length to allow the hydrant to be set at the proper elevation, as shown on the drawings. Extensions shall be furnished and installed at the Contractor's expense, when required for greater depths.
- G. Valve boxes shall be set plumb, flush with the ground or paved surface, and centered directly over the operating nut of the valves. Earth fill shall be carefully tamped around the valve boxes to a distance of 4 feet on all sides of the boxes or to the undisturbed trench face, if less than 4 feet.

- H. Valves shall be operational and accessible at all times during construction and warranty period. The Contractor shall verify proper operation of all valves in the presence of the Engineer and/or Owner following completion of the project and prior to the acceptance of substantial completion.

3.3 POLYETHYLENE ENCASEMENT:

- A. The pipe, hydrants and valves to be encased shall be thoroughly cleaned of all soil and debris prior to installation of the polyethylene encasement. No soil or debris shall be allowed to enter the encasement during or after its installation.
- B. Polyethylene encasement shall be installed using Method A as described in AWWA C105, with the encasement joints coincident with pipe joints. Adhesive tape shall be used to secure the encasement.
- C. Minimum overlap of polyethylene encasement shall be 24-inches, 12-inches on each side of pipe joints.
- D. If required, two layers of polyethylene encasement shall be installed. The first layer shall be completely installed on and secured to the length of pipe before the second layer is installed.
- E. Tears, cuts and other damage shall be repaired with a piece of polyethylene covering secured with adhesive tape, when approved by the Engineer. Otherwise, the damaged length of polyethylene shall be replaced at the Contractor's expense.
- F. Care shall be taken when backfilling to avoid damage to the polyethylene encasement.

END OF SECTION

SECTION 33 31 13.16

**POLYVINYL CHLORIDE GRAVITY PIPE AND FITTINGS
(SDR-35)**

PART 1 - GENERAL

1.1 WORK INCLUDED:

- A. This section covers the furnishing and installation of Polyvinyl Chloride (PVC) pipe and fittings, as indicated on the drawings and as specified herein.
- B. Work shall be performed in accordance with the City of Worcester Department of Public Works & Parks Standard Construction Specifications and Details. Should there be discrepancies between Section 33 31 13.16 and the City's Specifications and Details, the latter shall govern.

1.2 RELATED WORK

- A. Section 31 00 00, EARTHWORK
- B. Section 31 50 00, SUPPORT OF EXCAVATION
- C. Section 33 05 26.13, TRACER TAPE
- D. Section 33 31 13.37, VALVES AND APPURTENANCES FOR WASTEWATER WORK
- E. Section 33 39 13, PRECAST MANHOLES AND CATCH BASINS

1.3 REFERENCES:

- A. The following standards form a part of these specifications as referenced:

ASTM International (ASTM)

ASTMD2321	Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTMD3034	Specification for Type PSM Polyvinyl Chloride (PVC) Sewer Pipe and Fittings
ASTMD3212	Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals

1.4 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 00 SUBMITTAL PROCEDURES, SUBMIT THE FOLLOWING:

Manufacturer's literature of the materials of this section.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. A.PVC nonpressure sewer shall conform to ASTM D3034, all with SDR of 35 unless noted, and shall meet the specific requirements and exceptions to the aforementioned specifications that follow.
- B. PVC nonpressure sewer pipe shall be furnished in standard lengths.
- C. One pipe bell consisting of an integral wall section with a solid cross section rubber ring, factory assembled, shall be furnished with each standard, random and short length of pipe. Rubber rings shall be provided to the requirements of ASTM D3212.
- D. The rubber ring shall be retained within the bell of the pipe by a precision formed groove or recess designed to resist fishmouthing or creeping during assembly of joints.
- E. 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 jointing of the two pipes.
- F. PVC fittings shall be provided with bell and/or spigot configurations with rubber gasketed joints compatible with that of the pipe. Bend fittings with spigot ends shorter than the pipe recess bells will not be allowed. The shorter spigot end would not allow proper seating of the spigot in the mating bell and would permit undesired contact between the mating bell and the outside of the fitting bell.
- G. All pipe delivered to the job site shall be accompanied by independent testing laboratory reports certifying that the pipe and fittings conform to the above-mentioned specifications. In addition, the pipe shall be subject to thorough inspection and tests, the right being reserved for the Engineer to apply such of the tests specified as it may from time to time deem necessary.
- H. All cutting of pipe shall be done with a machine suitable for cutting PVC pipe. Cut ends shall be beveled when recommended by the pipe manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Except as modified herein, installation of the PVC pipe shall be in accordance with ASTM D2321.
- B. Each pipe length shall be inspected before being laid to verify that it is not cracked. Pipe shall be laid to conform to the lines and grades indicated on the drawings or given by the Engineer. 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.
- C. The pipe shall be supported by compacted crushed stone. Crushed stone shall be as specified under Section 31 00 00, EARTHWORK.
- D. The pipe shall not be driven down to grade by striking it with a shovel handle, timber, rammer, or other unyielding object. When each pipe has been properly bedded,

enough of the backfill material shall be placed and compacted between the pipe and the sides of the trench to hold the pipe in correct alignment.

- E. Before a joint is made, the pipe shall be checked to assure that a close joint with the next adjoining pipe has been maintained and that inverts are matched and conform to the required line and grade.
- F. For pipe placed on crushed stone, immediately after the joint is made, the jointing area shall be filled with suitable materials so placed and compacted that the ends of either pipe will not settle under backfill load.
- G. No pipe or fitting shall be permanently supported on saddles, blocking, or stones.
- H. Branches and fittings shall be laid by the Contractor as indicated on the drawings, and/or as required by the Engineer. Open ends of pipe and branches shall be closed with PVC caps secured in place with premolded gasket joints or as required by the Engineer.
- I. All pipe joints shall be made as nearly watertight as practicable. There shall be no visible leakage at the joints and there shall be no sand, silt, clay, or soil of any description entering the pipeline at the joints. Where there is evidence of water or soil entering the pipeline, connecting pipes, or structures, the defects shall be repaired to the satisfaction of the Engineer.
- J. The Contractor shall build a tight bulkhead in the pipeline where new work enters an existing sewer. This bulkhead shall remain in place until the Engineer authorizes its removal.
- K. Care shall be taken to prevent earth, water, and other materials from entering the pipe, and when pipe laying operations are suspended, the Contractor shall maintain a suitable stopper in the end of the pipe and also at openings for manholes.
- L. As soon as possible after the pipe and manholes are completed on any street, the Contractor shall flush out the new pipeline using a rubber ball ahead of the water, and none of the flushing water or debris shall be permitted to enter any existing sewer.

3.2 QUALITY CONTROL

A. LEAKAGE TESTING:

- 1. On completion of a section of sewer, including building connections installed to the property line, the Contractor shall install suitable bulkheads as required, dewater and test the sewer for leakage.
- 2. Unless otherwise approved, the section shall be tested using low pressure air test procedures. If circumstances permit, the Engineer may allow testing by infiltration or exfiltration in lieu of air testing.
- 3. 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. The two tables are reproduced on the following pages.

4. 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.
5. 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.
6. 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.
7. 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 insure that this test can be accomplished without danger of forcing stoppers from wye or tee branches.
8. 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.
9. 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.
10. The Contractor shall be responsible for the satisfactory watertightness 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.

B. PIPE DEFLECTION MEASUREMENT:

1. 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 Engineer 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.
2. 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 its own expense.

TABLE I

**SPECIFICATION TIME REQUIRED FOR A 1.0 PSIG PRESSURE DROP
FOR SIZE AND LENGTH OF PIPE INDICATED FOR Q=0.0015**

Pipe Diameter (in)	Minimum Time (min:sec)	Length for Min. Time (ft)	Length for Longer Length (sec)	Specification time for length (L) shown (min:sec)							
				<u>100 ft</u>	<u>150 ft</u>	<u>200 ft</u>	<u>250 ft</u>	<u>300 ft</u>	<u>350 ft</u>	<u>400 ft</u>	<u>450 ft</u>
4	3:46	597	.380 L	3:46	3:46	3:46	3:46	3:46	3:46	3:46	3:46
6	5:40	398	.854 L	5:40	5:40	5:40	5:40	5:40	5:40	5:42	6:24
8	7:34	298	1.52 L	7:34	7:34	7:34	7:34	7:36	8:52	10:08	11:24
10	9:26	239	2.374 L	9:26	9:26	9:26	9:53	11:52	13:51	15:49	17:48
12	11:20	199	3.418 L	11:20	11:20	11:24	14:15	17:05	19:56	22:47	25:38
15	14:10	159	5.342 L	14:10	14:10	17:48	22:15	26:42	31:09	31:09	35:36
18	17:00	133	7.692 L	17:00	19:13	25:38	32:03	38:27	44:52	51:16	57:41
21	19:50	114	10.470 L	19:50	26:10	34:54	43:37	52:21	61:00	69:48	78:31
24	22:40	99	13.674 L	22:47	34:11	45:34	56:58	68:22	79:46	91:10	102:33
27	25:30	88	17.306 L	28:51	43:16	57:41	72:07	86:32	100:57	115:22	129:48
30	28:20	80	21.366 L	35:37	53:25	71:13	89:02	106:50	124:38	142:26	160:15
33	31:10	72	25.852 L	43:05	64:38	86:10	107:43	129:16	150:43	172:21	193:53
36	34:00	66	30.768 L	51:17	76:55	102:34	128:12	153:50	179:29	205:07	230:46

TABLE II

**SPECIFICATION TIME REQUIRED FOR A 0.5 PSIG PRESSURE DROP
FOR SIZE AND LENGTH OF PIPE INDICATED FOR Q=0.0015**

Pipe Diameter (in)	Minimum Time (min:sec)	Length for Min. Time (ft)	Length for Longer Length (sec)	Specification time for length (L) shown (min:sec)							
				<u>100 ft</u>	<u>150 ft</u>	<u>200 ft</u>	<u>250 ft</u>	<u>300 ft</u>	<u>350 ft</u>	<u>400 ft</u>	<u>450 ft</u>
4	1:53	597	.190 L	1:53	1:53	1:53	1:53	1:53	1:53	1:53	1:53
6	2:50	398	.427 L	2:50	2:50	2:50	2:50	2:50	2:50	2:51	3:12
8	3:47	298	.760 L	3:47	3:47	3:47	3:47	3:48	4:26	5:04	5:42
10	4:43	239	1.187 L	4:43	4:43	4:43	4:57	5:56	6:55	7:54	8:54
12	5:40	199	1.709 L	5:40	5:40	5:42	7:08	8:33	9:58	11:24	12:50
15	7:05	159	2.671 L	7:05	7:05	8:54	11:08	13:21	15:35	17:48	20:02
18	8:30	133	3.846 L	8:30	9:37	12:49	16:01	19:14	26:26	25:38	28:51
21	9:55	114	5.235 L	9:55	13	17:27	21:49	26:11	30:32	34:54	39:16
24	11:20	99	6.837 L	11:24	17:57	22:48	28:30	34:11	39:53	45:35	51:17
27	12:45	88	8.653 L	14:25	21:38	28:51	36:04	43:16	50:30	57:42	46:54
30	14:10	80	10.683 L	17:48	26:43	35:37	44:31	53:25	62:19	71:13	80:07
33	15:35	72	12.926 L	21:33	32:19	43:56	53:25	64:28	75:24	86:10	96:57
36	17:00	66	15.384 L	25:39	38:28	51:17	64:06	76:55	89:44	102:34	115:23

END OF SECTION

SECTION 33 39 13

PRECAST MANHOLES AND CATCH BASINS

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. This Section covers all precast manholes and catch basins complete, including, but not limited to, bases, walls, cones, mortar, inverts, frames and covers.
- B. Work shall be performed in accordance with the City of Worcester Department of Public Works & Parks Standard Construction Specifications and Details. Should there be discrepancies between Section 33 39 13 and the City's Specifications and Details, the latter shall govern.

1.2 RELATED WORK

- A. Section 31 00 00, EARTHWORK
- B. Section 32 12 00, PAVING
- C. Section 03 05 00, FIELD CONCRETE

1.3 SYSTEM DESCRIPTION

- A. Precast sections shall conform in shape, size, dimensions, materials, and other respects to the details indicated on the drawings or as required by the Engineer.
- B. All manholes and catch basins shall have concrete bases. Concrete bases shall be precast unless otherwise specified. Invert channels shall be formed of brick and mortar upon the base.
- C. Catch basins shall have a 4-foot deep sump unless otherwise specified. Leaching basins shall have a bottom opening as shown on the drawings.
- D. Riser and cone sections shall be precast concrete.

1.4 REFERENCES

- A. The following standards form a part of this specification as referenced:

ASTM International (ASTM)

ASTM	A48	Standard Specification for Gray Iron Castings
ASTM	C32	Standard Specification for Sewer and Manhole Brick (Made From Clay or Shale)
ASTM	C144	Standard Specification for Aggregate for Masonry Mortar

ASTM C207	Standard Specification for Hydrated Lime for Masonry Purposes
ASTM C478	Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
ASTM C923	Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals
ASTMC990	Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTMC1244	Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill

Occupational Safety and Health Administration

OSHA 29 CFR 1910.27 Fall Prevention Protection

1.5 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 00 SUBMITTAL PROCEDURES, SUBMIT THE FOLLOWING:

- A. Manufacturer's literature of the materials of this section.
- B. Test reports as required by the Engineer.

PART 2 - PRODUCTS

2.1 PRECAST CONCRETE SECTIONS

- A. All precast concrete sections shall conform to ASTM C478 with the following exceptions and additional requirements:
 - 1. The wall thickness of precast sections shall be as designated on the drawings, meeting the following minimum requirements:

<u>Section Diameter (Inches)</u>	<u>Minimum Wall Thickness (Inches)</u>
48	5
60	6
72	7
84	8

- 2. Type II cement shall be used except as otherwise approved.
- 3. Sections shall be steam cured and shall not be shipped until at least five days after having been cast.
- 4. Minimum compressive strength of concrete shall be 4000 psi at 28 days.

5. No more than two lift holes may be cast or drilled in each section.
 6. The date of manufacture and the name or trademark of the manufacturer shall be clearly marked on the inside of each precast section.
 7. Acceptance of the sections will be on the basis of material tests and inspection of the completed product.
 8. Circumferential steel reinforcement in walls and bases shall be a minimum of 0.12 sq. in./lin. ft. for 4-foot diameter sections and 0.15 sq. in./lin. ft. for 5- and 6-foot diameter sections. Reinforcing shall extend into tongue and groove.
- B. Conical reducing sections shall have a wall thickness not less than 5-inches at the bottom and wall thickness of 8-inches at the top. Conical sections shall taper from a minimum of 48-inches diameter to 24 or 30-inches diameter at the top, as shown on the drawings.
- C. Except where insufficient depth of cover dictates the use of a shorter base, bases shall be a minimum of 4 feet in height.
- D. Slab top sections and flat riser sections (Grade Rings) shall conform to the contract drawings, with particular attention focused upon the reinforcing steel and be designed to meet or exceed an HS-20 Loading requirement.
- E. The tops of the bases shall be suitably shaped by means of accurate ring forms to receive the riser sections.
- F. Precast sections shall be manufactured to contain wall openings of the minimum size to receive the ends of the pipes, such openings being accurately set to conform with line and grade of the sewer or drain. Subsequent cutting or tampering in the field, for the purpose of creating new openings or altering existing openings, will not be permitted except as required by the Engineer.
- G. "Drop-over" manholes shall be placed where indicated on the drawings. The Contractor shall accurately measure the diameter of the existing outlet pipe and inform the manufacturer of its size, so that the "Drop-over" type opening can be cut into the precast manhole base. The bottom shall be cast in place by the Contractor in accordance with Section 03 05 00, FIELD CONCRETE. The invert channel shall be formed of brick and mortar, as specified in this specifications section. The sub-base shall be a compacted, level foundation of crushed stone, at least 6-inches thick, as specified in Section 31 00 00, EARTHWORK, but shall vary to the depth necessary to reach sound undisturbed earth.
- H. The exterior surfaces of all precast manhole bases, walls, and cones shall be given a minimum of one shop coat of bituminous dampproofing.
- I. The Engineer reserves the right to reject any unsatisfactory precast section and the rejected unit shall be tagged and removed from the job site immediately.
- J. The Engineer may also require the testing of concrete sections as outlined under Physical Requirements in ASTM C478 with the Contractor bearing all testing costs.
- 2.2 BRICK MATERIALS
- A. Brick shall be sound, hard, and uniformly burned brick, regular and uniform in shape and size, of compact texture, and satisfactory to the Engineer. Bricks shall comply with ASTM C32, for Grade SS, hard brick, except that the mean of five tests for absorption shall not exceed 8 percent by weight.

- B. Rejected brick shall be immediately removed from the work and brick satisfactory to the Engineer substituted.
- C. Mortar shall be composed of portland cement, hydrated lime, and sand in which the volume of sand shall not exceed three times the sum of the volumes of cement and lime. The proportions of cement and lime shall be as required by the Engineer and may vary from 1:1/4 for dense hard-burned brick to 1:3/4 for softer brick. In general, mortar for Grade SS Brick shall be mixed in the volume proportions of 1:1/2:4-1/2; portland cement to hydrated lime to sand.
- D. Cement shall be Type II portland cement as specified for concrete masonry.
- E. Hydrated lime shall be Type S conforming to ASTM C207.
- F. The sand shall comply with ASTM C144 specifications for "Fine Aggregate," except that all of the sand shall pass a No. 8 sieve.

2.3 FRAMES, GRATES, COVERS AND STEPS

- A. Castings shall be of good quality, strong, tough, even-grained cast iron, smooth, free from scale, lumps, blisters, sandholes, and defects of every nature which would render them unfit for the service for which they are intended. Contact surfaces of covers and frame seats shall be machined to prevent rocking of covers.
- B. All castings shall be thoroughly cleaned and may be subject to a careful hammer inspection at the Engineer's discretion.
- C. All construction castings shall meet the requirements of AASHTO M306 and shall be supplied by East Jordan Iron Works, Inc. – LeBaron Foundry or approved equal. All manufacturers will need their drawings and weights reviewed by Worcester DPW – Engineering to determine if the proposed item is equal.
- D. Catch Basin grate shall be EJIW 7288M or LeBaron L28SG1. Catch basin inlet frame shall be EJIW 7288Z (4- Flange), EJIW 7288Z1 (3-Flange) or LeBaron LF288, Type E.
- E. Manhole frame and cover shall be EJIW 1056Z frame and EJIW 1056A cover or LeBaron LC239/L23C-1. Nonbolted casting manhole covers shall be supplied with a closed pickhole and shall show the wording 'Worcester, A Town June 14, 1722: A City February 29, 1848' cast into said cover. Castings that are supplied bolted and watertight may have alternate lettering.
- F. Catch basin frames set against curbing shall have three flanges only.
- G. Manhole steps shall conform to ASTM C478 requirements and shall be fabricated of either extruded aluminum or steel reinforced plastic. Steps shall be uniformly spaced at a maximum of 12-inches unless otherwise shown on the drawings.

2.4 SEWER MANHOLE ACCESSORIES

- A. Gasket materials shall be top grade (100% solids, vulcanized) butyl rubber and shall meet or exceed ASTM C990.
- B. Couplings at the manhole-pipe interface shall be made with a rubber seal system (with or without stainless steel straps) meeting the requirements of ASTM C923 and recommended for this type of connection.

- C. Stubs installed as specified and indicated on the drawings shall be short pieces of the same class pipe as that entering the manhole and shall have either stoppers or end caps as shown on the drawings. Stoppers or end caps shall be especially designed for that application.

PART 3 - EXECUTION

3.1 INSTALLATION

A. PRECAST SECTIONS:

1. Precast bases shall be supported on a compacted level foundation of crushed stone, as specified in Section 31 00 00 EARTHWORK, at least 6-inches thick, but shall vary to the depth necessary to reach sound undisturbed earth.
2. Precast reinforced concrete sections shall be set vertical and with sections in true alignment.
3. Butyl rubber joint sealant shall be installed between each concrete section. Catch basin sections do not require joint sealant if so indicated on the drawings.
4. All holes in sections used for handling the sections shall be thoroughly plugged with mortar. Mortar shall be one part cement to 1-1/2 parts sand, mixed slightly damp to the touch (just short of "balling"), hammered into the holes until it is dense, and an excess of paste appears on the surface, and then finished smooth and flush with the adjoining surfaces.

B. BRICK WORK:

1. Bricks shall be moistened by suitable means, as required by the Engineer, until they are neither so dry as to absorb water from the mortar nor so wet as to be slippery when laid.
2. Each brick shall be laid as a header in a full bed and joint of mortar without requiring subsequent grouting, flushing or filling, and shall be thoroughly bonded as directed.
3. The brick inverts shall conform accurately to the size of the adjoining pipes. Side inverts shall be curved, and main inverts (where direction changes) shall be laid out in smooth curves of the longest possible radius which is tangent to the centerlines of adjoining pipe.

C. CASTINGS:

1. Cast iron frames, grates and covers shall be as specified. The frames and covers shall be set by the Contractor to conform accurately to the grade of the finished pavement, existing ground surface, or as indicated on the drawings. Frames shall be adjusted to meet the street surface.
2. Cast iron manhole frames and covers not located in paved areas shall be set 6-inches above finished grade, at a height as required by the Engineer, or as indicated on the drawings. The top of the cone shall be built up with a minimum of 1 course and a maximum of 5 courses of brick and mortar used as headers for adjustment to final grade.
3. Frames shall be set concentric with the top of the concrete section and in a full bed of mortar so that the space between the top of the concrete section or brick

headers and the bottom flange of the frame shall be completely filled and made watertight. A thick ring of mortar extending to the outer edge of the concrete shall be placed all around the bottom flange. The mortar shall be smoothly finished to be flush with the top of the flange and have a slight slope to shed water away from the frame.

4. Covers and/or grates shall be left in place in the frames, for safety reasons, except while work is being performed.

D. ACCESSORIES:

1. Accessories shall be installed in accordance with the manufacturer's instructions.
2. Stubs shall be set accurately to the dimensions indicated on the drawings. Stubs shall be sealed with suitable watertight plugs.

3.2 LEAKAGE TESTS

- A. Leakage tests shall be made by the Contractor and observed by the Engineer on each manhole. The test shall be by vacuum or by water exfiltration as described below:

B. VACUUM TEST:

1. The vacuum test shall be conducted 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

<u>Depth</u> <u>(Feet)</u>	<u>Diameter (Inches)</u>		
	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

2. If the manhole fails the initial test, the Contractor shall locate the leaks and make 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.

C. WATER EXFILTRATION TEST:

1. 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 blow 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.

2. 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 Engineer 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 Engineer 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 gallon 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 Engineer. The manhole shall then be retested and, if satisfactory, interior joints shall be filled and pointed.
3. 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 Engineer that the water table is below the bottom of the manhole throughout the test.
4. If the groundwater table is above the highest joint in the manhole, and there is no leakage into the manhole, as determined by the Engineer, such a test can serve to evaluate water-tightness of the manhole. However, if the Engineer is not satisfied with the results, the Contractor shall lower the water table and carry out the test as described hereinbefore.

3.3 CLEANING

All new manholes shall be thoroughly cleaned of all silt, debris and foreign matter of any kind, prior to final inspection.

END OF SECTION

SECTION 33 41 13.22

CORRUGATED POLYETHYLENE (HDPE) DRAINAGE PIPE

PART 1 – GENERAL

1.1 WORK INCLUDED

- A. This section includes furnishing all materials, labor and equipment and installing corrugated polyethylene [HDPE] drainage pipe and fittings as shown on the drawings and as specified herein.
- B. Work shall be performed in accordance with the City of Worcester Department of Public Works & Parks Standard Construction Specifications and Details. Should there be discrepancies between Section 33 41 13.22 and the City's Specifications and Details, the latter shall govern.

1.2 RELATED WORK

- A. Division 31, EARTHWORK
- B. Section 31 50 00, SUPPORT OF EXCAVATION

1.3 REFERENCES

- A. The following standards form a part of this specification, as referenced:

ASTM International (ASTM)

ASTM D2321	Standard for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications
ASTM F405	Standard Specification for Corrugated Polyethylene Pipe and Fittings
ASTM F667	Standard Specification for Large Diameter Corrugated Polyethylene Pipe and fittings

American Association of State Highway and Transportation Officials

AASHTO M294	Standard Specification for Corrugated Polyethylene Pipe
AASHTO MP6	Standard Specification for Corrugated Polyethylene Pipe 42" and 48" Diameter

1.4 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 00 SUBMITTAL PROCEDURES, SUBMIT THE FOLLOWING:

- A. Manufacturer's literature on the materials of this Section.
- B. Manufacturer's certification that the product was manufactured, tested, and supplied in accordance with this specification.

1.5 DELIVERY, STORAGE AND HANDLING

- A. Pipe shall be packaged to withstand shipment without damage and handled carefully on the jobsite. Pipe shall be stored so that it is not exposed to sunlight.

PART 2 – PRODUCTS

2.1 MATERIALS

- A. This Section applies to corrugated polyethylene pipe with an integrally formed smooth interior.
- B. The nominal size for the pipe and fittings is based on the nominal inside diameter of the pipe.
- C. The pipe and fittings shall be free of foreign inclusions and visible defects. Fittings may be either molded or fabricated. Fittings supplied by manufacturers other than the supplier of the pipe shall not be permitted without the approval of the Engineer. The ends of the pipe shall be cut squarely and cleanly so as not to adversely affect joining.

2.2 MANUFACTURERS

- A. Pipe and fittings shall be manufactured by Ipex, Inc.; Plexco, Division of Chevron Chemical Co.; J-M Pipe Co.; Advanced Drainage Systems, Inc. (ADS) or approved equal.

PART 3 – EXECUTION

3.1 INSTALLATION

- A. Pipe interiors, fitting interiors, and joint surfaces shall be thoroughly cleaned before installation. Pipes and fittings shall be maintained clean.
- B. Pipes shall be installed in the locations and to the required lines and grades shown on the drawings and provided in these Specifications, using an approved method of control.
- C. Excavations shall be maintained free of water during the progress of the Work. No pipes shall be laid in water, nor shall there be any joints made up in water.
- D. If any defective pipe is discovered after being placed, removal and replacement with sound pipe will be required at no additional cost to the Owner.

END OF SECTION

SECTION 33 44 19.13

STORMWATER TREATMENT SYSTEM

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. The Contractor shall furnish all labor, materials, equipment and incidentals required and install all precast concrete storm-water treatment systems and appurtenances in accordance with the Drawings and these specifications.
- B. Work shall be performed in accordance with the City of Worcester Department of Public Works & Parks Standard Construction Specifications and Details. Should there be discrepancies between Section 33 44 19.13 and the City's Specifications and Details, the latter shall govern.

1.2 RELATED WORK

- A. Section 03 05 00, FIELD CONCRETE
- B. Division 31, EARTHWORK
- C. Section 32 12 00, HOT MIX ASPHALT PAVING

1.3 QUALITY CONTROL INSPECTION

- A. The quality of materials, the process of manufacture, and the finished sections shall be subject to inspection by the Engineer. Such inspection may be made at the place of manufacture, or on the work site after delivery, or at both places, and the sections shall be subject to rejection at any time if material conditions fail to meet any of the specification requirements, even though sample sections may have been accepted as satisfactory at the place of manufacture. Sections rejected after delivery to the site shall be marked for identification and shall be removed from the site at once. All sections which have been damaged beyond repair during delivery will be rejected and, if already installed, shall be repaired to the Engineer's acceptance level, if permitted, or removed and replaced, entirely at the Contractor's expense.
- B. All sections shall be inspected for general appearance, dimensions, soundness, etc. The surface shall be dense, close textured and free of blisters, cracks, roughness and exposure of reinforcement.
- C. Imperfections may be repaired, subject to the acceptance of the Engineer, after demonstration by the manufacturer that strong and permanent repairs result. Repairs shall be carefully inspected before final acceptance. Cement mortar used for repairs shall have a minimum compressive strength of 4,000 psi when tested in accordance with ASTM C-109. Epoxy mortar may be utilized for repairs.

1.4 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 00
SUBMITTAL PROCEDURES, SUBMIT THE FOLLOWING:

A. Shop Drawings:

Structural design calculations and shop drawings, which shall be certified by a Professional Engineer retained by the system manufacturer or Contractor and licensed in the state where the system is to be installed.

B. Affidavit on patent infringement:

1. The Contractor shall submit to the Engineer, prior to installation of the stormwater treatment system, an affidavit regarding patent infringement rights stating that any suit or claim against the Owner due to alleged infringement rights shall be defended by the Contractor who will bear all the costs, expenses and attorney's fees incurred thereof.

C. Performance Documentation:

The following documentation must be submitted by the Contractor and approved by the Engineer prior to the manufacture and delivery of any materials.

1. Laboratory Data

The stormwater treatment system supplier shall provide documentation of Total Suspended Solids (TSS) removal efficiency from laboratory testing conducted on the supplier's full-scale system. The documentation shall include:

- a. TSS removal efficiency versus operating rate for the full operating range of the stormwater treatment system for a uniform 50-micron particle size.
- b. TSS removal calculations for each system specified herein. The calculations must demonstrate that the system(s) is capable of achieving a net annual TSS removal efficiency as required by local regulations and as based upon a uniform 50-micron particle size and the best available rainfall data for the project site location.

2. Field Test Data

The stormwater treatment system supplier shall provide documentation of TSS removal efficiency from field testing conducted on an installed system. The documentation shall be in accordance with the following:

- a. The testing and documentation shall have been conducted by an independent third party.
- b. The testing and documentation shall include at least 10 storms.
- c. The testing and documentation must show TSS removal results that meet or exceed the performance requirements for the system(s) specified herein.

3. Manufacturing Experience

The stormwater treatment supplier shall provide evidence of at least 5 years of successful product design and use. The supplier shall provide an installation list of projects, model sizes installed and installation dates where the same type systems as specified herein have been designed and produced by the supplier.

D. Operation and Maintenance Manuals:

Furnish four copies of the operation and maintenance manuals for the stormwater treatment systems.

PART 2 - PRODUCTS

2.1 MATERIALS AND DESIGN

- A. Concrete for precast storm-water treatment systems shall conform to ASTM C 857 and C 858 and meet the following additional requirements:
 - 1. The wall thickness shall not be less than 6-inches or as shown on the dimensional drawings. In all cases the top slab and wall thickness shall be no less than the minimum thickness necessary to sustain HS20-44 loading requirements as determined by a Licensed Professional Engineer.
 - 2. Sections shall have tongue and groove or ship-lap joints with a butyl mastic sealant conforming to ASTM C 990.
 - 3. Cement shall be Type II Portland cement conforming to ASTM C 150.
 - 4. All sections shall be cured by an approved method. Sections shall not be shipped until the concrete has attained a compressive strength of 4,000 psi or until 5 days after fabrication and/or repair, whichever is the longer.
 - 5. Pipe openings shall be sized to accept pipes of the specified size(s) and material(s), and shall be sealed by the Contractor with a rubber seal system meeting the requirements of ASTM C923.
- B. Internal aluminum plate components shall be ¼-inch (6 mm) thick aluminum alloy 5052-H32 in accordance with ASTM B 209.
- C. Internal aluminum angle components shall be ¼-inch (6 mm) thick aluminum alloy 6063 in accordance with ASTM B 308.
- D. Brick or masonry used to build the manhole frame to grade shall conform to ASTM C 32 or ASTM C 139 and shall be installed in conformance with all local requirements.
- E. Casting for manhole frames and covers shall be in accordance with ASTM A48, CLASS 30B and AASHTO M105.
- F. A bitumen sealant in conformance with ASTM C 990 shall be utilized in affixing the aluminum swirl chamber to the concrete vault.

2.2 PERFORMANCE

- A. Unless otherwise indicated, all equipment used shall be capable of providing the design treatment rate and , sediment storage volumes listed in the schedule on the Drawings. Proposed equipment shall be submitted in writing to the Engineer, along with sufficient data supported by certified tests that the system can meet the end results shown in on the drawings and this specification section. The stormwater treatment system shall be CDS Model by Contech or approved equal.
- B. Each stormwater treatment system shall include a circular aluminum "swirl chamber" (or "grit chamber") with a tangential inlet to induce a swirling flow pattern that will accumulate and store settle-able solids in a manner and a location that will prevent re-suspension of previously captured particulates.
- C. Each stormwater treatment system shall be of a hydraulic design that includes flow controls designed and certified by a professional engineer using accepted principles of fluid mechanics that raise the water surface inside the tank to a pre-determined level in order to prevent the re-entrainment of trapped floating contaminants.

- D. Each stormwater treatment system shall be capable of removing 80% of the net annual Total Suspended Solids (TSS) load based on a uniform 50-micron particle size. Annual TSS removal efficiency models shall be based on documented removal efficiency performance from full scale laboratory tests. Annual TSS removal efficiency models shall only be considered valid if they are corroborated by independent third party field testing. Said field testing shall include influent and effluent composite samples from a minimum of ten storms at one location. Individual stormwater treatment systems shall have the Design Treatment Capacity listed in Table 2.02, and shall not resuspend trapped sediments or reentrain floating contaminants at flow rates up to and including the specified Design Treatment Capacity.
- E. Individual stormwater treatment systems shall have usable sediment storage capacity of not less than the corresponding volume listed in Table 2.02. The systems shall be designed such that the pump-out volume is less than ½ of the total system volume. The systems shall be designed to not allow surcharge of the upstream piping network during dry weather conditions.
- F. A feature shall be incorporated into the design of the stormwater treatment system to prevent the introduction of trapped oil and floatable contaminants to the downstream piping during routine maintenance and to ensure that no oil escapes the system during the ensuing rain event. Direct access shall be provided to the sediment and floatable contaminant storage chambers to facilitate maintenance. There shall be no appurtenances or restrictions within these chambers.
- G. The stormwater treatment system manufacturer shall furnish documentation which supports all product performance claims and features, storage capacities and maintenance requirements.
- H. Stormwater treatment systems shall be completely housed within one structure.

2.3 MANUFACTURER

- A. Each stormwater treatment system shall be of a type that has been installed and used successfully for a minimum of 5 years. The manufacturer of said system shall have been regularly engaged in the engineering design and production of systems for the physical treatment of stormwater runoff during the aforementioned period.
- B. Each stormwater treatment system shall be a Contech CDSTM System as manufactured by Contech Construction Products Inc., 9025 Centre Pointe Drive - Suite 400, West Chester, Ohio 45069. Any substitution shall be submitted with the required performance data for review by the Engineer before it can be approved.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Each stormwater treatment system shall be constructed according to the sizes shown on the Drawings and as specified herein. Install at elevations and locations shown on the Drawings or as otherwise required by the Engineer.
- B. Place the precast base unit on a granular subbase of minimum thickness of six inches after compaction or of greater thickness and compaction if specified elsewhere. The granular subbase shall be checked for level prior to setting and the precast base

section of the trap shall be checked for level at all four corners after it is set. If the slope from any corner to any other corner exceeds 0.5% the base section shall be removed and the granular subbase material re-leveled.

- C. Prior to setting subsequent sections place bitumen sealant in conformance with ASTM C 990-91 along the construction joint in the section that is already in place.
- D. After setting the base and wall or riser sections, install the circular swirl chamber wall by bolting the swirl chamber to the side walls at the three (3) tangent points and at the 3-inch wide inlet tab using HILTI brand concrete anchors or equivalent 1/2-inch diameter by 2-3/4-inch minimum length at heights of approximately 3-inches off the floor and at the mid-height of the completed trap (at locations of pre-drilled holes in aluminum components). Seal the bottom edge of the swirl chamber to the trap floor with the supplied aluminum angle flange. Adhere 1/4-inch thick by 1-inch wide neoprene sponge material to the flange with half of its width on the horizontal leg of the flange and half of its width on the vertical leg. The aluminum angle flange shall be affixed to the floor with a minimum 3/8-inch diameter by 2-3/4-inch drop in wedge anchor at the location of the predrilled holes. Affix the swirl chamber to the flange with hex head 1/4-inch x 1-1/2-inch zinc coated self- tapping screws at the location of the predrilled holes. Seal the vault sidewalls to the outside of the swirl chamber from the floor to the same height as the inlet pipe invert using butyl mastic or approved equal.
- E. Prior to setting the precast roof section, bitumen sealant equal to ASTM C 990 shall be placed along the top of the baffle wall, using more than one layer of mastic if necessary, to a thickness at least 1-inch greater than the nominal gap between the top of the baffle and the roof section. The nominal gap shall be determined either by field measurement or the shop drawings. After placement of the roof section has compressed the butyl mastic sealant in the gap, finish sealing the gap with an approved non-shrink grout on both sides of the gap using the butyl mastic as a backing material to which to apply the grout. Also apply non-shrink grout to the joints at the side edges of the baffle wall.
- F. After setting the precast roof section of the storm-water treatment system, set precast concrete manhole riser sections, to the height required to bring the cast iron manhole covers to grade, so that the sections are vertical and in true alignment with a 1/4-inch maximum tolerance allowed. Backfill in a careful manner, bringing the fill up in 6-inch lifts on all sides. If leaks appear, clean the inside joints and caulk with lead wool to the satisfaction of the Engineer. Precast sections shall be set in a manner that will result in a watertight joint. In all instances, installation of Storm-water Treatment Systems shall conform to ASTM specification C 891 "Standard Practice for Installation of Underground Precast Utility Structures".
- G. Holes made in the concrete sections for handling or other purposes shall be plugged with a nonshrink grout or by using grout in combination with concrete plugs.
- H. Where holes must be cut in the precast sections to accommodate pipes, do all cutting before setting the sections in place to prevent any subsequent jarring which may loosen the mortar joints. The Contractor shall make all pipe connections.

END OF SECTION

SECTION 33 44 26

UNDERGROUND STORMWATER CHAMBER SYSTEM

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. The Contractor shall furnish all labor, materials, equipment and incidentals required and install the underground stormwater chamber system and appurtenances in accordance with the Drawings and these specifications.
- B. Work shall be performed in accordance with the City of Worcester Department of Public Works & Parks Standard Construction Specifications and Details. Should there be discrepancies between Section 33 44 26 and the City's Specifications and Details, the latter shall govern.

1.2 RELATED WORK

- A. Section 31 00 00, EARTHWORK

1.3 QUALITY CONTROL INSPECTION

- A. The quality of materials, the process of manufacture, and the finished sections shall be subject to inspection by the Engineer. Such inspection may be made at the place of manufacture, or on the work site after delivery, or at both places, and the sections shall be subject to rejection at any time if material conditions fail to meet any of the specification requirements, even though sample sections may have been accepted as satisfactory at the place of manufacture. Sections rejected after delivery to the site shall be marked for identification and shall be removed from the site at once. All sections which have been damaged beyond repair during delivery will be rejected and, if already installed, shall be repaired to the Engineer's acceptance level, if permitted, or removed and replaced, entirely at the Contractor's expense.
- B. All sections shall be inspected for general appearance, dimensions, soundness, etc. The surface shall be dense, close textured and free of blisters, cracks, roughness and exposure of reinforcement.
- C. Imperfections may be repaired, subject to the acceptance of the Engineer, after demonstration by the manufacturer that strong and permanent repairs result. Repairs shall be carefully inspected before final acceptance.

1.4 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF SECTION 01 33 00 SUBMITTAL PROCEDURES, SUBMIT THE FOLLOWING:

- A. Shop Drawings

Structural design calculations and shop drawings, which shall be certified by a Professional Engineer retained by the system manufacturer or Contractor and licensed in the state where the system is to be installed.

B. Performance Documentation

The following documentation must be submitted by the Contractor and approved by the Engineer prior to the manufacture and delivery of any materials.

1. Manufacturing Experience

The stormwater chamber supplier shall provide evidence of at least 5 years of successful product design and use. The supplier shall provide an installation list of projects, model sizes installed and installation dates where the same type systems as specified herein have been designed and produced by the supplier.

C. Operation and Maintenance Manuals

Furnish four copies of the operation and maintenance manuals for the stormwater treatment system. Operation and Maintenance procedures shall be as specified by the manufacturer.

PART 2 - PRODUCTS

2.1 MATERIALS AND DESIGN

- A. Chamber, stone and fabric materials and design shall conform to those indicated on the drawings, or, if applicable, in shop drawings and installation instructions provided by the system manufacturer.

2.2 MANUFACTURER

- A. Each stormwater chamber system shall be of a type that has been installed and used successfully for a minimum of 5 years. The manufacturer of said system shall have been regularly engaged in the engineering design and production of systems for the physical collection of stormwater runoff during the aforementioned period.

2.3 STORMWATER PRETREATMENT COMPONENTS

- A. The stormwater pretreatment component of the underground stormwater chamber system has been designed to meet the requirements of the Massachusetts Stormwater Handbook and has been approved by the local Conservation Commission. Configuration of the stormwater pretreatment component of the system must be as indicated on the plans in order to comply with local approval. If the Contractor wishes to propose an alternative pretreatment approach, the Contractor must secure approval from the local Conservation Commission for the alternative approach at no additional cost to the owner.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Each stormwater chamber system shall be constructed according to the sizes shown on the Drawings and as specified herein. Install at elevations and locations shown on the Drawings or as otherwise required by the Engineer.

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- B. Installation of Chambers, stone and fabric shall be completed as indicated in the manufacturer's installation instructions.

END OF SECTION

SECTION 34 40 00

TRAFFIC CONTROL SIGNALS

PART 1 - DESCRIPTION

1.1 WORK INCLUDED

This work shall consist of furnishing and installing or modifying at each location, traffic control signals ready for operation.

Included in the work is the furnishing and installing or modifying existing traffic signal control equipment, signal heads, electric lamps, pedestrian push buttons, control equipment, vehicle detectors, posts and bases, poles, pedestals, mast arms, strain pole and span wire assemblies and all incidental materials (included in Subsection 801: Conduit, Manholes, Handholes, Pull Boxes and Foundations and Subsection 813: Wiring, Grounding and Service Connections) necessary for operating the traffic control signals.

This work shall also include furnishing and erecting any pertinent signs and all painting required to complete the installation. The removal, salvage, stockpiling, reinstallation or transporting of existing traffic installations will be covered under this section and appropriate pay items where applicable.

The locations of signal heads, controllers, standards and appurtenances shown on the plans are approximate and exact locations will be established by the Engineer in the field.

The responsibility for the exact and satisfactory installation of traffic signals shall rest with the Contractor and work performed, if not acceptable by the Engineer, shall be executed to the satisfaction of the Engineer by the Contractor at the Contractor's expense.

All electrical equipment shall be designed, manufactured and tested in accordance with the applicable standards of the ANSI, IMSA, ITE, NEMA, UL and these Specifications.

All work and materials shall conform to the requirements of the Massachusetts Electrical Code herein referred to as the electrical code.

Wherever reference is made to codes or standards mentioned above, the reference shall be construed to mean the code or standard that is in effect on the date of advertising of the project.

All work within the traffic control cabinet shall be done by an IMSA Certified Traffic Signal Level II Technician. The Contractor shall provide to the Engineer names and certification qualifications of all persons who will be working within the traffic control cabinet at least 10 days prior to the start of any traffic control cabinet work.

Standard symbols and construction details for traffic signal installations are shown on the current Traffic Signal and Highway Lighting Standard Drawings.

Within 30 days following execution of the Contract, the Contractor shall submit to the Engineer for approval, a list of equipment they propose to install. The submission shall include all equipment identified on the plans or in the specifications by the name of the manufacturer, model or identifying number of

each item. The list shall be supplemented by catalog cuts and such other data as may be required, including wiring diagrams of any special equipment and any proposed minor deviation from the plans. All the above data shall be submitted in triplicate for checking. Following checking, correction and review, not less than 5 complete approved sets shall be resubmitted to the Engineer for distribution. The Department shall not be liable for any material purchased, labor performed, or delay to the work prior to such review and approval.

The Contractor shall provide the Department, within 10 days of receipt of approval, written proof that they have ordered the Traffic Control Signal Devices required by this Section.

Shop drawings are required for all structural support materials and fabricated items that are not specifically detailed on the plans. Shop Drawings are not required for items that are on the QTCE.

The warranties that the Contractor receives from each manufacturer of equipment and materials pertinent to the complete and satisfactory operation of traffic signal installation shall be turned over to the Department at the time of acceptance of the project, at no cost to the Department. Each warranty so furnished shall indicate its expiration date and be in effect for a minimum period of one year from the date traffic signals were placed in continuous operation.

If within one year from the date the traffic signal system is placed on continuous operation the equipment and materials do not meet the warrants specified above and the Engineer notifies the manufacturer or their authorized representative promptly, the manufacturer or their authorized representative thereupon shall correct any defect either by repairing or replacing any defective part or parts, at no cost to the Department.

The Contractor shall, at their own expense, replace any part of the traffic signal control equipment found to be defective in workmanship, material or manner of functioning within six months from the date of final acceptance of all the installations.

It is the intent of the Plans and Specifications to provide a complete traffic control signal system throughout the project.

It is not intended that every fining, minor detail or feature be shown and described, as the assumption is made that either the Contractor or their Subcontractor is an expert in the particular area of responsibility and is capable of interpreting the plans and specifications so that the bid shall include all items required and that they shall be provided and installed in a neat and workmanlike manner.

Any installation of wiring by the Contractor will be performed by licensed electricians.

1.2 EQUIPMENT

All new equipment including controllers with cabinets, vehicle detectors and detector amplifiers shall be furnished, except as noted, and installed by the Contractor.

No equipment or accessories specified in Subsection 815: Traffic Control Signals will be accepted unless type tested and approved by the Department prior to the date of the proposal.

The Department will list annually all equipment and accessories that have been type tested approved and/or approval withdrawn.

Such approval by the Department of equipment or accessories. however. shall not relieve the Contractor of any responsibility required under Section 5.00: Control of Work. All approvals will be conditional, and the Department reserves the right to withdraw its approval of equipment or accessories at any time for any of the following reasons:

- a. Subsection 815: Traffic Control Signals. Delivery of equipment or accessories which do not meet requirements of Subsection 815: Traffic Control Signals.
- b. Equipment or accessories with abnormal maintenance and performance records.

PART 2 - MATERIALS

2.1 GENERAL

The materials required are those specifically covered in the plans and in accordance with Division III of the Standard Specifications.

Any and all signs required shall conform to Subsection 828: Traffic Signs and the MUTCD. All materials shall be new and of the latest design.

Any equipment that has been type tested and approved by the Department (815.21: Equipment) will be considered as meeting these specifications.

Where existing systems are to be modified. the existing equipment and material shall be incorporated in the revised system. salvaged or abandoned as directed by the Engineer in writing.

2.2 CONTROLLERS

See SECTION 34 40 01.

2.3 MAST ARMS – STRAIN POLES AND SPAN WIRE ASSEMBLIES

See SECTION 34 40 01.

2.4 POSTS AND BASES

- A. Standard Signal Post shall consist of a 4-in. shaft complete with an octagonal base (8 ft or 10 ft long including base).
- B. Pedestal Signal Post shall consist of a 4-in. shaft complete with a pedestal base (8 ft or 10 ft long including base).
- C. All posts and their bases shall be of the same material, either steel or aluminum. Aluminum signal posts shall utilize a tapered shaft.

2.5 VEHICLE SIGNAL HEADS

See SECTION 34 40 01.

2.6 PEDESTRIAN SIGNAL HEADS

See SECTION 34 40 01.

2.7 LOUVERED HOOD AND OPTICALLY PROGRAMMED ADAPTORS

See SECTION 34 40 01.

2.8 TRAFFIC SIGNAL LAMPS

See SECTION 34 40 01.

PART 3 - EXECUTIONS

3.1 GENERAL

Details of construction shall conform to all applicable requirements of the Standard Specifications and drawings, plans, details, manufacturer's instructions and directions of the Engineer.

3.2 PAINTING

- A. All painting required shall be done in conformance with applicable portions of 960.63: Painting.
- B. Aluminum posts, pedestals, poles, standards or mast arms shall not be painted. All galvanized surfaces shall not be painted unless abraded or damaged at any time after the applications of the zinc coating. The surfaces shall then be repaired by thoroughly wire brushing the damaged areas and removing all loose and cracked coatings after which the cleaned areas shall be painted with two coats of paint, conforming to the requirements of M7.04.11.
- C. All traffic signal, highway lighting and related electrical equipment (except new traffic signal controller cabinets) that comes from the manufacturer with one or more coats of paint (excluding primer) will be accepted, as one coat if scars or abraded places are properly cleaned and spot coated.
- D. Two additional coats of paint shall then be applied. If such equipment is painted at the factory with just a primer coat, the Contractor shall apply three coats of paint.
- E. Paint shall be applied to all interior surfaces before equipment and appurtenances are installed and to all exposed parts of the equipment and appurtenances after they have been completely installed, using the following colors:

Controller Cabinets (Exterior)	Aluminum
Controller Cabinets (Interior)	White
Signal Posts (Exterior Steel)	Yellow
Signal Posts (Interior Steel)	Aluminum
Mast Arm and Mast Arm Pole (Exterior)	Aluminum
Mast Arm and Mast Arm Pole (Interior)	Aluminum
Housings (Back)	Yellow
Housings (Front)	Black
Visors (Outside)	Yellow
Visors (Inside)	Dull Black

Backboards	Dull Black
Louvers	Dull Black
Meter Sockets.....	Aluminum

Painting may be omitted if equipment and materials are received from the manufacturer with equivalent paint specified above. All scars and abrasions shall be spot coated with two coats of the specified paint.

- F. Steel poles (inner and outer surfaces) shall be painted in accordance with the applicable provisions of the Specifications.
- G. All surfaces of aluminum bases in contact with concrete shall be coated, in the field, with a protective coating recommended by the manufacturer of the base.

3.3 SIGNALS

- A. Signal posts, bases, mast arms, mast arm shafts and strain poles shall be handled in loading, unloading and erecting in such a manner that they will not be damaged. Any parts that are damaged due to the Contractor's operations shall be repaired or replaced at the Contractor's expense.
- B. Posts, bases, mast arms and strain poles shall not be erected on concrete foundations until the concrete has set for at least three days.
- C. Mast arms and strain poles shall be raked sufficiently to be plumb after all loads have been placed, poles shall be raked by adjusting double nuts. Shims or similar devices for plumbing or raking will not be permitted.
- D. The bottom of the housing assembly of a signal head not mounted over a roadway shall not be less than 8 ft nor more than 15 ft above the sidewalk or, if none, above the pavement grade at the center of the roadway.
- E. The bottom of the housing assembly of a signal head suspended over a roadway shall not be less than 16 ft nor more than 19 ft above the pavement grade at the center of the roadway.
- F. Each signal face shall consist of one or more sections, rigidly and securely fastened together, capable of being positioned to face one direction of traffic.
- G. Each section shall be a self-contained assembly consisting of a housing with door, visor and optical unit (lens and reflector) with traffic signal lamp.

3.4 SIGNAL HEAD SECTION

- A. Each section shall be constructed to the requirements of ANSI specified in 815.46: Pedestrian Signal Heads including the following:
 - 1. Optical units for 8-in. sections shall be equipped with traffic signal lamps as specified in 815.48: Traffic Signal Lamps
 - 2. Optical units for 12-in. sections shall be equipped with traffic signal lamps as specified in 815.48: Traffic Signal Lamps.
 - 3. Optical units for optically programmed sections shall be equipped with traffic signal lamps as specified in 815.48: Traffic Signal Lamps, equipped with dimming device to reduce lumen output of each signal lamp for night time operations.
- B. Signal faces containing sections with both 8-in. and 12-in. lenses may be required. All signal heads including multiple assemblies shall be completely shop assembled

and delivered ready for erection. Multiple units shall be assembled using 1.5-in. pipe for the supporting framework and include 1.5- in. center supporting pipe for post top mountings. Span wire and mast arm units shall have approved tie braces for the lower framework without a center support. Welding shall not be used in frame assembly.

- C. Each socket shall be wired with two #18 AWG stranded leads not less than 16 ft long conforming to the requirements of 813.40: General for Type 5 traffic signal head wire. Type TFF or TEW.
- D. The color of the leads from the socket behind the:
 - Red lens - 1 red and 1 white wire
 - Yellow lens - 1 yellow and 1 white wire
 - Green lens - 1 green and 1 white wire
 - Green arrow - 1 blue and 1 white wire
- E. At the option of the manufacturer, approved connecting blocks may be installed inside the housing for these connecting wires, provided a 16-ft colored lead for each socket and 1 white common lead is furnished as an integral part of each housing.

3.5 HANGARS AND ADAPTERS

- A. Hangers and adaptors shall be of bronze or malleable iron. or other approved material. strongly constructed. and of hollow design to permit the suspension of signal heads from mast arms or span wires or mounted on brackets, posts or pedestals.
- B. Signal heads intended for post or pedestal mounting shall have suitable slip fitters for post top mounting and be secured to posts by means of set screws.
- C. Mast arm mounted signal heads shall have an approved universal joint and safety chain.
- D. Bracket mounted signal heads shall have suitable brackets to attach them to timber or metal poles to permit either internal or external wiring. Brackets shall be of proper size to be properly attached to pole as shown on the Standard Drawings.
- E. Span-wire mounted signal heads shall have a span-wire hanger similar in design to that shown on the Standard Drawings. Hanger shall be specifically designed for supporting a hanging object from steel stranded messenger cable and have "U" bolts to prevent lateral movement only. Each hanger shall be complete with a wire entrance device.
- F. Where specified, integral terminal compartments shall be provided for any of the above types of mounting. Terminal compartments shall be fabricated of non-frangible metal and be of adequate size to accommodate a terminal block containing not less than twelve poles. each with two pressure type connectors. Each connector shall be capable of holding four #12 AWG conductors.

3.6 BACKPLATES

Where stipulated. backplates shall be furnished and installed. Backplates shall be constructed of anodized half hard aluminum sheet 0.06-in. nominal thickness and of the dimensions to fit the signal head housing used.

3.7 POLE CLAMPS

When required for mounting signal heads or equipment. pole clamps shall conform to the general design shown on the Standard Drawings.

3.8 CONTROLLERS

- A. All controller cabinets. control equipment and accessories shall be factory wired ready for operation. Field work will be limited to placing cabinets and equipment and the connecting of field wiring to terminal strips. Cabinets shall be mounted on the foundation and a clear silicone sealer shall be used at the base of the cabinet to form a water-tight seal with the foundation.
- B. In addition, the Contractor shall provide to the Engineer 2 copies of the Operating and Maintenance Instruction Manuals complete with wiring diagrams of the internal. external and field connections for each type of controller furnished on the project and listed in 815.41: Controllers two copies of the Technical Manuals and "Box Prints" for each type of controller furnished on the project and listed in 815.41: Controllers.

3.9 DETECTORS

- A. The Contractor shall install the detectors at the locations as shown on the signal layout plan in accordance with the applicable requirements of the Department's Standard Drawings.
- B. All detector lead-in cable shall be continuous without splices from the pull box nearest the detector to the controller cabinet terminals provided without passing through any signal bases.
- C. Splices, when necessary in the pull box nearest the detector shall be soldered and made completely watertight using an approved rigid body re-enterable closure.
- D. Detector leads shall not be run in the same cable sheath (jacket) with wires carrying signal currents.
- E. Magnetic Detector Multi-Lane. shall be installed inside a 3-in. Type NM conduit, 18 in. below the surface of the road in a cement concrete envelope not less than 4 in. thick at any point as shown on the Standard Drawings.
- F. Magnetic Detector Single Lane shall be installed in accordance with manufacturer's instructions.
- G. Ultra-Sonic Detectors shall be installed overhead on mast arms or on posts (side-fired) in close conformity with the required lines and grades.
- H. Wire-Loop and Micro-Loop Detectors shall be installed in slots saw-cut in the pavement and oriented to the traffic lane.
- I. The size and type of conductor and method of installation shall conform to the Department's Standard Drawings.
- J. The saw-slots shall be filled with an approved roadway loop embedding sealer to protect the wire.

3.10 DISPOSAL OF EXISTING EQUIPMENTS

- A. When removal of existing traffic signal equipment and appurtenances is called for, the order of work shall be as directed by the Engineer. Removal of existing traffic signal equipment and their accessories shall be done in a manner that will not damage reusable material.
- B. All signal posts and bases shall be separated from one another without damage to either unit (4-in. shaft unscrewed from base).
- C. When stipulated, existing material shall be utilized in the construction of the new installation. Material to be installed shall be thoroughly cleaned before reinstallation. All reinstalled material, after cleaning and spot coating, shall receive two brush coats of paint to all parts as specified for new installations. Paint shall be applied after material is in place.
- D. The Contractor shall furnish and install all necessary materials and equipment, including new foundations, etc. required to complete the reinstallation.
- E. All traffic signals, flashing beacons and pedestrian signals to be reinstalled shall be relamped with new lamps of the size and type required for new installations.
- F. Existing material removed and not utilized in the new installation shall be salvaged and transported by the Contractor to the Department Storeroom.
- G. Underground conduit, conductors, foundations and detector frames not reused shall be removed from the project, except if not interfering with other construction, they may with written approval of the Engineer be abandoned in place.

3.11 TESTS REQUIRED BEFORE ACCEPTANCE

- A. The Contractor shall record and make a written report of the following tests to be made on all traffic control signal installations in the presence of the Engineer:
 - 1. Resistance Test required by 813.62: Grounding Electrodes.
 - 2. An insulation resistance 500V megger test shall be made for each inductive loop sensor and lead-in at the controller cabinet where the combination is to be terminated.
- B. The following test procedure shall be performed in the presence of the Engineer before and after the loop sensor is sealed in the pavement as detailed below.
- C. The cost of equipment, labor, and materials to perform such testing and similar re-testing following repairs, replacement, or adjustment of any detector assembly within the project area shall be included in the price bid for the Traffic Control Signal installation for that location, or under Item 819.831 if applicable.
- D. After installation of wire loop sensors in the roadway and installation of shielded lead-in connecting the loop sensors to the terminals in the controller cabinet. each loop sensor and lead-in combination shall be tested (at the controller cabinet before termination) for proper installation.
- E. The resistance from lead to lead of the same loop sensor shall not exceed 3 ohms per 1,000 ft as measured by a high-quality meter suitable for measurements of low resistance.
- F. A megohm-meter test at 500 VDC shall be made between the two leads of a loop/lead-in combination temporarily spliced together, but otherwise disconnected from all terminals, and the shield drain wire and then the earth ground connection.

These resistances shall be recorded and shall be equal to or greater than 100 megohms. The lowest acceptable value shall be 80 megohms under certain worst-case conditions as determined by the Engineer.

- G. A megohm-meter test at 500VDC shall be made between lead-in shield and earth ground connection. This resistance should be at least 100 megohms. The lowest acceptable value shall be greater than 50 megohms under worst case conditions as determined by the Engineer.
- H. If any loop sensor lead-in combination fails to pass any one of the above four tests. it shall be repaired and then re-tested on two occasions at least two weeks apart. and then shall pass on each re-test occasion.
- I. If the loop sensor lead-in combination does not pass all these re-tests, a new loop sensor and/or lead-in shall be installed, and then shall pass all tests. at no additional cost.
- J. After the above tests have been satisfactorily completed. all loop sensor/shielded lead-in inductances shall be measured and a written report of the results shall be filed with the Engineer and a copy stored with the "Box Prints" at the intersection along with a copy of the ground electrode resistance tests required by 813.62: Grounding Electrodes, Paragraph B and the above.
- K. Operation Tests - After satisfactory completion of the required tests, the system(s) shall be placed in operation.
- L. Final acceptance will not be made until the system(s) has operated satisfactorily, as designed and the timing has been fine tuned. for a period of not less than 30 days from a date designated by the Engineer.
- M. This test period shall be included within the specified contract time. Operation of the system(s) shall not in any way be construed as an acceptance of the system(s), or any part of it, or as a waiver of any of the provisions of the contract.
- N. The Contractor shall be responsible for the system(s) during this period of operation and they shall make any adjustments or repairs that may be required and remedy defects or damages which may occur, at their own expense.

3.12 AS-BUILT DRAWINGS

- A. Upon completion of the work. the Contractor shall mark and submit 5 complete copies of "as built" or corrected copies of the contract plans (copies for marking furnished by the Department), showing in detail all construction changes, especially locations and depths of conduit and locations of posts, standards, handholes, manholes and pull boxes. All "as built" drawings shall be dated.
- B. Manufacturer's instructions for the maintenance, servicing and operation of all equipment, wiring diagrams of all equipment (except traffic signal controllers specified in 815.41: Controllers) and a parts list sufficient for the ordering of any parts and any other data thereof as required by the Engineer.

Copies to be distributed as follows:

- 1. City of Worcester DPW (1 complete set)
- 2. Control Cabinet (1 set as described in 2. above) with Technical Manuals and "Box Prints" required by in 815.41: Controllers).

END OF SECTION

SECTION 34 40 01

SPECIAL PROVISIONS - TRAFFIC CONTROL SIGNAL

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. The Contractor shall furnish all labor, materials, equipment, and incidentals required to make ready for use the complete traffic control system, and as required by the Engineer and as specified hereinafter.

It is the intent of these specifications that the traffic control system shall be suitable in every way for the service required. All material and all work which may be reasonably implied as being incidental to the work of this section shall be furnished at no extra cost to the Owner.

- B. The work shall include furnishing and installing the following:

1. Location #1 - The new traffic control signal equipment located at the intersection of Southbridge Street/Madison Street/Fire Station Driveway as shown on the plans. The equipment to be furnished and installed at the intersection listed above includes signal post, signal heads, and foundation, pull boxes, conduit, wire and cable, handholes; all cable and wiring; ground rods, equipment grounding and bonding; an emergency preemption system and all other equipment, materials and incidental materials and costs necessary to furnish, install and program a complete and functioning traffic control system as specified and as shown in the contract documents.

All existing traffic signal equipment at the intersection of Southbridge Street and Madison Street as shown on the drawings shall be remain and any damage incurred during the installation of the new emergency preemption system into the existing traffic signal control cabinet, or installation of the LED Blank Out Sign shall be repaired or replaced by Contractor at no additional cost to the Owner.

- C. It is the intent of these specifications that the traffic control system shall be suitable in every way for the service required. All material and all work which may be reasonably implied as being incidental to the work of this section shall be furnished at no extra cost to the Owner.
- D. The work under this item shall be in accordance with the provisions of Section 800 Traffic Control Systems of the MassDOT STANDARD SPECIFICATIONS FOR HIGHWAYS AND BRIDGES dated 2025, The latest version of the MassDOT SUPPLEMENTAL SPECIAL PROVISIONS, THE 2023 MANUAL OF UNIFORM TRAFFIC CONTROL DEVICES with the latest revisions and the latest MassDOT STANDARD DRAWINGS FOR OVERHEAD SIGNAL STRUCTURE & FOUNDATION, dated 2015.
- E. A list of major items and/or work required is included on the plans.

1.2 RELATED WORK

- A. The Contractor's attention is directed to the General Conditions, Supplementary Conditions, and the Scope & Sequence of Work.
- B. Excavation and backfilling required for underground electrical work is included under Division 2.

1.3 CODES, INSPECTIONS, PERMITS AND FEES

- A. All material and installations shall be in accordance with the latest edition of the Massachusetts Electrical Code (527 CMR 12.00) and all applicable local codes and ordinances.
- B. Obtain all necessary permits and pay all fees for permits and inspections.

1.4 SUBMITTALS: IN ACCORDANCE WITH REQUIREMENTS OF GENERAL SPECIFICATIONS, SUBMIT THE FOLLOWING:

- A. Complete submittals and shop drawings as per the MassDOT Standard Specifications Section 815.20 General Traffic Control Devices shall be submitted.
- B. The manufacturer's name, product designation or catalog number, descriptive literature, and data shall be submitted.
- C. Prior to submittal, all shop drawings shall be checked for accuracy and conformance to contract requirements. Shop drawings shall bear the date checked and shall be accompanied by a statement that the shop drawings have been examined for conformity to the specifications and drawings. This statement shall also list all discrepancies with the specifications and drawings. Shop drawings not so checked and noted shall be returned.
- D. The Engineer's review shall be only for conformance with the design concept of the project and compliance with the specifications and drawings. The responsibility of, and the necessity of, furnishing materials and workmanship required by the specifications and drawings which may not be indicated on the shop drawings is included under the work of this section.
- E. The responsibility for all dimensions to be confirmed and correlated at the job site and for coordination of this work with the work of all other trades is also included under the work of this section.

1.5 ELECTRIC SERVICES

- A. Service connections shown on the plans are approximate only. The Contractor shall determine exact locations from the servicing utility, arrange to complete the service connections, and be responsible for all charges incidental thereto.
- B. All work and material for the services, shall be in accordance with the requirements of the electric utility. Service connections shown on the plans are approximate only. The Contractor shall determine exact locations from the servicing utility, arrange to complete the service connections, and be responsible for all charges incidental thereto. A 100-ampere meter socket approved by the servicing utility company shall be furnished and installed on the side of the control cabinet by the serving utility company. A 3-inch PVC Conduit shall be installed from the controller cabinet to the utility pole, or manhole, which will supply electrical service to the controller cabinet.

This conduit shall be encased in concrete where crossing roadways and/or driveways. All work and material for the services, shall be in accordance with the requirements of the electric utility.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Materials used in all systems shall be new, unused, and as hereinafter specified. All materials, where not specified, shall be of the very best of their respective kinds. Samples of materials or manufacturer's specifications shall be submitted for review as required by the Engineer. Materials and equipment used shall be Underwriters' Laboratories, Inc. listed.
- B. All uprights, cabinets and other above ground signal equipment shall be finished black with polyester powder paint applied after a seven stage pretreatment process to ensure maximum durability. Signal heads, doors, visors, mounting brackets, and hardware supplied direct from the manufacturer in the color stipulated above may be acceptable provided it meets or exceeds the finish process for the material indicated below.

STEEL EQUIPMENT

GALVANIZING

All bolts, screws, nuts, rods and washers shall be galvanized in accordance with AASHTO M232 and the Standard Specifications. The hardened machine screws may be electroplate galvanized. Stainless steel studs, bolts, screws, nuts, straps and washers shall not be galvanized. Galvanized hardware need not be painted; however, the ends of bolts, nuts, and washers shall be painted in the field according to section "Touch-up and Repairs." Immediately prior to galvanizing, the steel shall be immersed in a bath of zinc ammonium chloride. The dry kettle galvanizing process shall be used.

All steel components, other than above, shall be galvanized after fabrication in accordance with AASHTO M111. The galvanizing bath shall contain nickel (0.05% to 0.09% by weight) in accordance with subsection 960.61 of the Standard Specifications.

Galvanized members requiring shop assembly shall be welded and drilled prior to galvanizing.

COATING OVER GALVANIZED STEEL

Prior to painting, the applicator shall ensure that all components are smooth and without sharp protrusions that would present an injury hazard to pedestrians. Also, the fabricator shall ensure that all welds shall be cleaned thoroughly in accordance with good practice and according to AWD D1.5 and ASTM A123-89a and shall have a suitable surface to accept the galvanizing.

In preparation for the two coat painting system, the surface shall be blast cleaned in accordance with the requirements of SSPC SP7 "Brush-Off Blast Cleaning" or other method producing equivalent results and uniform profile, to achieve a 1.0 to 1.5 mils anchor profile as indicated by a Keane Tator profile comparator or similar device. The creation of the anchor profile shall be performed prior to the formation of "white rust" on the galvanized surface.

SPECIAL PROVISIONS - TRAFFIC CONTROL SIGNAL

Following blast cleaning, the zinc coating thickness shall be measured to verify that the coating thickness is in accordance with AASHTO M111.

A two-coat painting system shall be applied by the Galvanizer in his own facility within twelve hours of galvanizing the steel components.

The prime coat material shall be a polyamide epoxy applied to minimum dry film thickness of 2.0 to 4.0 mils (0.002-0.004 in.) and force cured as given below for the finish coat.

The finish coat material shall be a two component, catalyzed aliphatic urethane applied by airless spray to a minimum dry film thickness of 4.0 mils.

The color shall be Black. The fabricator shall submit to the Engineer for approval, paint chips of the intended color prior to any work being done under this heading.

All finish coat material shall be applied under conditions within the following tolerances:

1. Air Temperature: 50°F min., 90°F max.
2. Surface Temperature: 50°F min., 100°F max.
3. Surface temperature must be at least 5°F above the dew point.

The finish coat shall be cured in a booth capable of maintaining 150°F for 2-4 hours.

TOUCH-UP AND REPAIRS

Should any damage occur to the galvanized coating during shipping or handling at the job site, the Contractor shall repair and touch-up any damaged areas as required by the Engineer and the following:

Touch-up of galvanizing before the finish coat is applied shall be accomplished by applying galvanizing repair paint in accordance with Section M7.04.11. The dry film thickness of the applied repair paint shall not be less than 4.0 mils.

Applications shall be in accordance with the manufacturer's instruction.

Field touch-up procedures shall conform to the recommendations of the galvanizer. Touch-up of the finish coat shall be by applying a coating of a two-part urethane, as supplied by the Galvanizer, to achieve a dry film thickness of at least 4.0 mils. Prior to the application of the paint, remove all damaged coatings down to a solidly adhered coating and apply galvanizing repair paint as primer.

Allow the primer to dry for at least 4 hours prior to top coating.

The Contractor shall also use the touch-up paint material and procedures to paint the galvanized hardware used in field erection that has not been finish coated previously.

ALUMINUM EQUIPMENT

All aluminum equipment called for shall have a powder coat finish. The coating shall be a polyester-TGIC (triglycidyl isocyanurate) resin system conforming to the following:

Quality	Test	Limits
Abrasion	Taber abraser CS-10, 1000 gram load, 1000 cycle, ASTM D4060	100 mg. Maximum weight loss
Adhesion	ASTM D .59	
	Initial	5A
	1000 hours	5A
Gloss	ASTM D 523	
	60° - 600 hours	82% retention
	60° - 1000 hours	90% retention (washed)
Hardness	ASTM D 3363	2H – No Gouge
Impact	ASTM D 2794 Direct	Pass 80 inch-lb.
Salt Spray Resistance	ASTM B 177	
	ASTM D 1654	
	1000 hours unscribed	Table 2-10
	400 hours scribed	Table 1-10
Weather Resistant	ASTM G 23, 1000 hours, 18 min. waterspray, 102 min. light	No film failure
Color	Black	
Identify	Infrared fingerprint	Match
Flexibility	180° bend; ½" dia, mandrel within 10 seconds	No breaks, flaking or cracks. Tested with a Q-panel with 2 mils or less of coating
Humidity	ASTM D 2247, 1000 hours	No blister or film failure
Thickness		4 mils +/- 1 mils
Mar Resistance		Good

A Certificate of Compliance of the powder coating system is required for the Engineer's approval.

B. Testing of Grounding System

The Contractor shall perform testing of the equipment grounding system in the presence of the Engineer in accordance with MassDOT Standard Specifications.

C. Pull Boxes and Handholes

The Contractor shall furnish and install of electric handholes, pull boxes, frames, and covers for the traffic signal system in accordance with the plans and as required by the Engineer.

Electrical Handholes, frames, and covers shall meet MassDOT standard SD2.022. Pull boxes, frames, and covers shall meet MassDOT standard SD2.031.

Electric handholes and pull boxes associated shall have "TRAFFIC" embossed on the cover per MassDOT standards.

D. Flashing Operation

Changes from automatic flashing to stop-and-go operation and from stop-and-go to automatic flashing operation shall occur as set forth in the MUTCD.

- E. The Traffic Control System equipment shall at all times during construction be adequately protected against mechanical injury or damage by water. If any apparatus has been damaged, such damage shall be repaired at no additional cost. If any apparatus has been subject to possible injury by water, it shall be thoroughly dried out and put through such special tests as required by the Engineer, or shall be replaced at no additional cost to the Owner.
- F. TRAFFIC SIGNAL EQUIPMENT
- The traffic signal controller unit (CU), malfunction management unit (MMU) and all other ancillary traffic signal control components included in the traffic control cabinet shall comply with the National Electrical Manufacturers Association (NEMA) Standard No. TS 2-2003 (r2008) v02.06 Amendment 4-2102, Traffic Controller Assemblies with National Transportation Communications for ITS Protocol (NTCIP) Requirements.
- G. LOAD SWITCHES
- Load switches shall comply with Subsection 6.2 of the NEMA TS 2 Standard. All load switches shall utilize optically isolated encapsulated modular solid-state relays. Discrete components on circuit boards are not acceptable.
- Load switch indicator lights shall be LED-type and wired on the input side of the device.
- Note: The controller cabinet assembly shall be initially supplied with a full complement of load switches to accommodate each available position of the back panel.
- H. FLASHER
- Flashers shall comply with Subsection 6.3 of the NEMA TS 2 Standard and be equipped with two output indicator lights which will show flashing power out to the cabinet assembly.
- I. FLASH TRANSFER RELAYS
- Flash transfer relays shall comply with Subsection 6.4 of the NEMA TS 2 Standard.
- The field electrical loading for flash operation shall be wired through the transfer relays such that the load on the 2-circuit flasher is as balanced as possible within the limitations of the signal phasing.
- Note: The controller cabinet assembly shall be initially supplied with a full compliment of flash transfer relays to accommodate each available position of the back panel.
- J. BACKPLATES
- Louvered backplates shall be provided on all signal heads as noted on the plans. The top, bottom and sides of all backplates shall measure from five to six inches in width. No louvers shall be closer than 1/2-inch from the inner edge of the backplate panel. Louver orientation shall be vertical on sides and horizontal on top and bottom.
- Backplates shall have a dull black finish on the side oriented with the signal face. The back side of the backplate shall match the color of the signal housing.
- Retro reflective borders shall be provided on all backplates.
- All backplates shall include 3-inch wide, yellow reflective micro-prismatic retroreflective sheeting conforming to ASTM D4956 Type VIII of better on the outside edge of the backplates.

The retro reflective border shall be placed no closer than ½-inch from all louvers. No sheeting is allowed over any louvered areas.

K. EMERGENCY VEHICLE PREEMPTION

The emergency vehicle preemption control system shall consist of a data-encoded phase selector to be installed within the traffic control cabinet. This unit will serve to validate, identify, classify and record the signal from the optical detectors located on support structures at the intersection. Upon receiving a valid signal from the detector, the phase selector shall generate a preempt call to the controller initiating a preemption operation as shown on the plans.

(Note: The make and model of the preemption system shall meet the approval of the Town of Easton. As part of the shop drawing submission the Contractor shall supply documentation, in writing, from the City that the preemption equipment supplied meets their approval)

(Note: The cable for the preemption system shall be separate from the cable associated with the traffic signal system)

The optical detectors shall be single input, single output units used to control one approach.

The phase selector shall be a rack-mounted plug-in four channel, dual priority device. The phase selector shall plug into a shelf-mounted single card slot chassis. Programming the phase selector shall be via a PC-based computer utilizing unit specific software. One copy of software, on 8cm or 12cm CD shall be supplied and licensed to the Town of Easton. A hard copy of final programming data shall be left in the control cabinet. The CONTRACTOR shall supply a complete set of interface cables for phase selector to laptop connection.

The CONTRACTOR shall install plunger style activator buttons inside the Fire Station as noted on the plans to be used to control the approach from the Fire Station.

The CONTRACTOR shall provide wireless transmitters to work with the proposed preemption system as noted on the plans to be used in the Fire Trucks when leaving the Fire Station.

The CONTRACTOR shall install a confirmation strobe at the traffic signal location as shown on the plans. The confirmation strobe shall serve to validate to the driver of the emergency vehicle that the traffic signal has recognized the preemption call and will initiate the proper preemption sequence. The confirmation strobe shall be a white lens.

The CONTRACTOR shall be responsible for the proper programming of the phase selector, orientation of the optical detectors, and all other work necessary to provide a complete and operating emergency vehicle preemption system. The CONTRACTOR may be required to field adjust the location of the optical detectors in the presence of the Engineer and the Town of Easton Department of Public Works Engineering Division to properly detect preemption calls from approaching vehicles.

L. SIGNAL POLES AND FOUNDATIONS

Signal poles and foundations shall be fabricated and constructed in conformance with the plans.

Signal poles shall be Type 2 Black Painted Steel with shoe bases.

Signal pole foundations, the standard signal pole foundation shall be modified to a concrete cored foundation.

Signal pole foundations shall not obstruct a sidewalk or crosswalk so that passage by physically challenged persons is not impaired.

M. POSTS AND BASES

Signal posts and bases shall be in accordance with MassDOT Standards.

N. SIGNAL HEADS

Signal heads shall be rigid mounted on mast arms, with the bottom of all signals at the same height. All traffic signal lenses shall be 12-inches in diameter unless otherwise noted on the plans. Louvered backplates shall be 5-inches provided on all signal heads as noted on the plans. All signal heads shall be equipped with light emitting diode (L.E.D.) 12" modules as noted on the plans.

Signal heads shall be made of aluminum. Signal heads shall be painted black in accordance with MassDOT standards with cut tunnel visors unless otherwise noted on the major items list on the plans.

Red, Yellow, and Green LED Vehicle Signal Modules

Any equipment that has been type-tested and approved according to section 815.21 of the Standard Specifications prior to the date of award of this contract will be considered as meeting these specifications.

All Red, Yellow and Green LED signal housings with the exception of optically-programmed and fiberoptic housings shall conform to the following:

All Red and Green LED signal modules shall conform to "Interim LED Purchase Specification of the Institute of Transportation Engineers, Vehicle Traffic Control Signal Heads – Part 2: Light Emitting Diode (LED) Vehicle Traffic Signal Modules", July 1998, or most current version, Institute of Transportation Engineers (ITE), 525 School Street, SW, Suite 410, Washington, DC, 20024-2797.

Yellow LED signal modules shall conform to the above specifications with the exception that

Traffic Signal LED Module

All signal and pedestrian displays shall be equipped with LED signal modules. All red, amber, green, and pedestrian signal housings with the exception of optically programmed and fiber optic housings and shall conform to the following where applicable:

ITE's Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Arrow Traffic Signal Supplement, Dated July 1, 2007

ITE's Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement, Dated June 27, 2005.

ITE's Pedestrian and Countdown Signal Modules Compliant to PTCSI - Part 2 Light Emitting Diode (LED), Dated, February 2011

On the MassDOT Traffic Signal Approved Equipment List

Energy Star / EPACT Program Requirements for Traffic Signals

On the MassDOT Traffic Signal Approved Equipment List

An independent lab shall certify that the LED signal module complies with the applicable ITE specification. The independent report should be submitted to MassDOT for review unless the module is already on the approved list.

For an LED module to be installed on this project, the LED module shall have approval from the MassDOT Traffic Control Products Approved Equipment Committee and be included on the Traffic Control Products List prior to the date of this proposal

To prevent the LED module warranty from being voided, the connecting leads on the module shall not be cut. The original LED module leads shall be connected to the signal head terminal block as continuous wire without splices.

The LED signal module will be replaced or repaired by the manufacturer if it exhibits one of the following:

A failure due to workmanship or material defects within the first 60 months of field operation.

A greater than 40 percent light output degradation or a fall below the minimum intensity levels (as defined by the latest ITE performance specifications) within the first 36 months of field operation

O. SOFTWARE

All local controller, malfunction management unit, loop detector amplifier and emergency vehicle preemption software shall be supplied with the latest available revision. Any software upgrades released by the manufacturer shall be supplied at no charge to the Town of Easton for a period of five years after acceptance of the traffic signal installation.

P. DOCUMENTATION

Each programmable local hardware component (i.e. controller, malfunction management unit, loop detector amplifier, emergency vehicle preemption phase selector) shall be initially programmed by the Contractor based on information contained on the plans. Note: Three bound sets of hard copy programming per device shall be supplied to the Town of Easton by the CONTRACTOR.

Upon final acceptance of the signal by the CITY, the CONTRACTOR shall supply two (2) 8½"x11" or 11"x17" laminated copies of the final traffic signal design plan and sequence and timing chart. One to be given to the Town of Easton Transportation Director and one to be left in the cabinet documentation envelope mounted on the inside of the cabinet door.

Q. MAINTENANCE OF TRAFFIC SIGNALS

It shall be the responsibility of the Contractor to provide all labor, equipment and material required for the maintenance of full repair of all temporary and proposed traffic control equipment within the project limits, including damage by automobile accident. The maintenance responsibility shall commence from the date the Contractor begins work on or near an existing signal and shall continue until the date when the Engineer recommends acceptance of the completed job.

For the purposes of these paragraphs, the phrase "Traffic Signal Control Equipment" is intended to include, but is not limited to: controllers, detectors, signal housings, supporting structures, cabinets, wires, conduit and all other ancillary electrical equipment used for traffic control.

R. CONDUIT

Conduits shall be 3" diameter Type NM- Plastic – (UL). PVC conduits shall be gray, Schedule 40 as specified, meeting the requirements of UL 651 and NEMA TC-2. All conduits placed under roadways, and subject to vehicular traffic, shall be back filled with excavatable flowable fill and encased in sand per construction details.

S. WIRE AND CABLE

All conductors shall be annealed copper, 98% conductivity, Class B stranded, except conductors used for power and lighting circuits No. 10 AWG and smaller which may be solid. All conductors should be rated for 600 volts or less, with a thermal rating of 90°.

The outside covering of all wiring for power, lighting, grounding, and control uses shall be color coded to identify polarity.

T. WIRE AND CABLE CONNECTORS AND DEVICES

Wire and cable connectors and devices shall meet the requirements of UL 486. Connectors, including miscellaneous nuts, bolts, and washers shall be silicon bronze. Ferrous materials shall not be used.

U. TRAFFIC HANDHOLES, FRAMES, & COVERS.

Traffic handholes are to be reinforced concrete with factory cored openings for conduit. Minimum handhole inside dimension shall be 12-inches width x 24-inches length x 33-inches deep.

Handholes shall be provided with skid-resistant surface covers, with an "Traffic" logo. Handholes, frames, and covers shall be design for street-rated, heavy duty applications, meeting the requirements of the either: AASHTO HS-20 or ANSI/SCTE 77-220 Tier 15 loading, with a minimum design load of 22,500 lbs for both the handhole box and cover. Covers shall include recessed stainless steel captive bolts of a penta-head design. The nuts for the bolts shall be self-centering and corrosion resistant. Handholes shall meet the requirements of the latest edition of the National Electric Code (2011 or later) with regards to structural integrity, installation methods, grounding of the cover and metallic parts, etc. Handholes shall be UL listed for the intended use.

Handholes to be installed flush with final grade. A layer of 6-inches of crushed stone shall be installed in the bottom of each handhole to assist with drainage, and this compacted gravel base material shall extend out beyond the sidewalls of the handhole.

PART 3 - EXECUTION

3.1 GENERAL:

- A. Contractor is responsible for coordinating work with other trades and the Owners schedule. Work will be coordinated such that systems can be properly located, and conflicts and delays are avoided. Contractor shall consider commencement of work acceptance of existing conditions.
- B. Contractor to meet with local wiring inspector prior to the start of any work and obtain any local site requirements and restrictions, which must be followed. Contractor shall also meet with local utility, any other City officials, as directed by

Owner and wire inspector, prior to the start of work, or ordering of materials. Failure to meet with the local officials and utility prior to ordering materials and start of construction will be considered negligent and all necessary corrections resulting from this failure will be at no cost to Owner.

- C. Work shall be executed in workmanlike manner and shall present neat, rectilinear and mechanical appearance when completed. Do not run raceway exposed unless shown exposed on Drawings. Material and equipment shall be new and installed according to manufacturer's recommended best practice so that complete installation shall operate safely and efficiently.
- D. Do not interrupt existing services without Owner's and Engineer's approvals.
- E. Contractor is responsible for removal and legal disposal of all existing traffic signal system equipment as indicated on the drawings.

3.2 INSTALLATION

TRAFFIC CONTROL SYSTEM

The Traffic Control System shall be installed in conformance as per the MassDOT Standard Specifications Section 801, Section 813 and Section 815.

3.3 GROUNDING

Bond and ground equipment and systems connected under this Section in accordance with standards of the NEC and other applicable regulations and codes.

Conduit system shall be electrically continuous throughout, grounded at service entrance. Equipment frames, enclosures, boxes, etc. shall be grounded by use of green-jacketed (or bare copper) ground, sized as per Table 250-95 of the NEC.

Green bonding jumper shall be installed in flexible conduits.

Copper fittings for ground connections shall conform to the requirements of ASTM B 30. All bolts, u-bolts, cap screws, nuts, and lock washers for copper fitting shall be of approved corrosion-resisting material. Compression connectors required for all below-grade grounding connections. Exothermic (cad-weld) connectors are also acceptable for use below grade. The use of bolted grounding and ground rod connectors below grade is not acceptable.

Ground Rods shall be 5/8-inch diameter and 8' in length, copperweld as required by applicable codes (NEC, NESC). Bonding connections to ground rods shall be permanent, welded or crimped, with copper connectors. All wire used for grounding shall be no smaller than #4 Awg copper, stranded conductor. Contractor shall bond all meter enclosure cabinets, meter sockets, safety disconnects, conduit grounding bushes, etc.

3.4 RECORD DRAWINGS

As the work progresses, legibly record (red line) all field changes on a set of project contract drawings. Prior to Substantial Completion of the project, submit the red lined prints to the Engineer for use in preparation of the record drawings.

3.5 TESTS AND ADJUSTMENTS:

Test all systems furnished under Division 16 and repair or replace all defective work. Make all necessary adjustments to the systems and equipment to the satisfaction of the Engineer.

The Contractor's attention is directed to requirements of the various sections of Division 16 for additional test specifications.

END OF SECTION

SECTION 34 40 02

TRAFFIC CONTROL DEVICES - CONDUIT, MANHOLES, HANDHOLES, PULL BOXES AND FOUNDATIONS

PART 1 - GENERAL

1.1 GENERAL

The work under this section shall consist of furnishing and installing and/or constructing the following in accordance with the requirements of the specifications, as directed on the plans and as directed by the Engineer.

- A. Conduits or ducts, intended for use as raceways for the installation of wires and cables, shall be 3-in. nominal size.
 - 1. Type NM: Rigid Non-Metallic (Bituminous Fiber, Fire Clay Cement, or Plastic) shall be used for all underground runs. When Type NM Electrical Conduit is specified either of the Types NM Electrical Conduit listed under M5.07.0: Electrical Conduit-Rigid Nonmetallic (Type NM) may be used in the work, at the option of the Contractor, but only one type shall be used throughout any one contract.
 - 2. Type RM: Rigid Metallic (Steel, Steel Plastic Coated, Special Alloys or Aluminum) shall be used for all above ground runs and where augured or jacked conduit is required. When specified for underground use or to be encased in concrete, conduit shall be plastic coated or manufactured from metal inherently resistant to corrosion.
 - 3. Type FM: Flexible Metallic (Steel or Steel Plastic Coated) shall be used where flexibility and special applications are required.
- B. Junction Boxes or Pull Boxes shall be of such dimension as shown on the Standard Drawings. Other designs shall not be used. Pull Boxes shall be installed in all conduit or duct runs over 150 ft in length, where there is an abrupt change in direction, grade or elevation, to provide a direct one conduit entrance for wire and cable into signal, mast arm or strain pole foundations, and as directed by the Engineer.
- C. Electric Manholes as shown on the Standard Drawings, plans, and/or as directed by the Engineer.
- D. Foundations for light standards, lighting load centers, standard signal posts, pedestal signal posts, mast arms, strain poles and control cabinets.

PART 2 - PRODUCTS

Materials shall meet the requirements specified in the following Subsections of Division III, Materials:

Cement and Cement Concrete Materials.....	M4
Pipe, Culvert Sections, Conduit and Fittings, Pull and Junction	M5
Paint and Protective Coatings	M7
Metal, Related Materials, Cast Iron Frames and Covers	M8

Gravel M1.03.0, Type c

Metallic pull and junction boxes may be cast iron, welded sheet steel or cast aluminum, with gasketed covers securely fastened with monel or stainless-steel screws that will, with cover in place, be watertight. Cast iron or sheet steel boxes shall be hot dipped galvanized conforming to the applicable portions of ASTM A153.

PART 3 - CONSTRUCTION METHODS

3.1 CONDUIT

A. Excavating Trench

The conduit shall not be placed until after the gravel subbase for the roadway has been constructed and the rolling thereof has been completed.

The trench for a single conduit line shall be excavated to a width of 18 in. to a depth not less than 36 in. below the proposed grade of the finished pavement as shown on the plans. Whenever 2 or more conduit lines are to be laid in the same trench, the trench shall be excavated to the width shown on the plans or as specified in the Special Provisions. If the condition of the bottom of the excavated trench is wet, clayey or spongy, or otherwise unsatisfactory, the Engineer may require that the bottom of the trench be excavated deeper and the space filled with clean gravel to form a firm bearing for the conduit. The gravel shall be firmly compacted in layers not over 6 in. in depth. The grade of the finished trench shall be parallel to the proposed pitch of the traffic conduit or duct.

Existing pavements shall be sawcut in accordance with the requirements of Subsection 482: Sawcutting as shown on the plans and as required by the Engineer.

B. Preparation of Bed

After the trench has been excavated to the proper width and depth as specified above, a gravel foundation 6 in. in depth shall be constructed on the bottom of the trench to provide a proper cushion for the conduit. This cushion of gravel shall be thoroughly tamped.

C. Laying Conduits

All conduit lines shall be direct from one end to the other, no bends being allowed except when entering a pull box or signal base. Whenever 2 or more conduit lines are to be laid in the same trench, the conduits shall be separated from each other by a minimum distance of 3 in.

D. Joints

All joints shall be made in accordance with conduit or duct manufacturer's recommendations, NEMA, UL and the MEC.

E. End Markers

Dead ends of conduit lines shall be plugged with wooden, plastic or fibre stoppers. To mark the ends, sections of 2-in. by 4-in. studs, long enough so as to project above the surface of the ground after the trench has been backfilled, shall be set vertically before the backfill is placed. For single conduit lines, the stud shall be butted directly against the stopper in the end of the conduit. Where 2 or more conduit lines converge to a common point, each line shall be ended 2 ft from the common point of

intersection and a stud set up at this point. Backfill shall not be placed until the Engineer has established the necessary ties to the studs.

F. Concrete Envelope

All Type NM Conduits or ducts marked "X" on the plans shall be encased in a concrete envelope as shown on the Standard Drawings.

G. Filling Trench

Gravel fill shall be made around the sides of the conduit and over it for a depth of 3 in. and thoroughly tamped. A plank of spruce, fir, hemlock or other satisfactory wood, about 6 in. wide and 2 in. thick, (nominal dimensions) shall be placed over this gravel and the filling of the trench with suitable materials in layers of not over 6 inches, compacted thoroughly, shall be completed. If Extra Heavy Wall (Schedule 80) Conduit is selected as an option for Rigid Non-Metallic Conduit, an approved underground warning tape may be substituted for the 2-in. by 6-in. plank.

H. Testing Installation

After the trench is backfilled, the Contractor shall, in the presence of the Engineer, test the installation by pushing or pulling through the entire length of the conduit line a rod, rope or fish tape on the end of which is attached a brush and ball with a diameter not smaller than $\frac{1}{4}$ in. less than the inside diameter of the conduit. All obstructions, including stones, dirt, concrete, etc., shall be removed, and damaged conduits shall be replaced at the expense of the Contractor.

I. Conduit and Duct Crossing Paved Roadways

When a trench has been cut across a paved surface, the trench shall be bridged with a 6-in. concrete slab as shown on the Standard Drawings.

When jacking or drilling methods are specified for placing conduits under existing pavements, pavement shall not be disturbed without the approval of the Engineer. In the event obstructions are encountered, upon approval of the Engineer, small test holes may be cut in the pavement to locate the obstructions. Jacking or drilling pits shall be kept 3 ft clear of the edge of any type pavement wherever possible.

J. Conduit on Structures

Conduit system on structures shall consist of furnishing and installing all material and equipment and performing all work necessary for a complete conduit system. The type of conduit shall be as

designated on the plans conforming to the requirements of M5.07.1: Electrical Conduit-Rigid Metallic (Type RM). All conduit bends shall be made in a neat and workmanlike manner. crushed or deformed conduit shall not be used. Conduit ends shall be reamed to remove all burrs, and all chips resulting from reaming removed from the conduit before installation. The ends of all conduit runs shall be protected by grounding bushings and be capped if wire and cable is not to be installed immediately. Conduit shall be held rigidly in place to prevent misalignment during placing of concrete. Reinforcing bars shall not be cut, bent, displaced or otherwise altered from that shown on the design plans. One manufactured expansion fitting (made of material compatible with the conduit) shall be used for each conduit run on structures at every expansion joint of the structure, unless flexible metallic conduit loops or bends are stipulated. Clamps or hangers shall be provided at intervals not exceeding 5 ft.

Conduit runs shall be made with the minimum practicable number of bends. The total of the angles of bends between junction or pull boxes shall not exceed 270°. So far as practicable, all bends shall be formed by the use of factory standard radius elbows. For metal conduit, where special angles of bends or offset bends are required, they may be formed to a radius of not less than 6 times the nominal inside diameter, provided the bend is made on a pipe bending machine. Field bends may be made by the use of a conduit bender forming curves the minimum radius of any portion of which shall not be less than 12 times the nominal inside diameter. Short radius bends shall be accomplished by the use of junction boxes or special condulets. Hot bends or other methods of bending which will destroy the protective coating on the metal conduit will not be permitted.

Conduit in which the cross-sectional area has been reduced or which contains sharp kinks will be rejected. Conduit shall be continuous from outlet to outlet; however, the runs may be interrupted by condulets placed for the purpose of pulling conductors or making short radius bends. All metal conduit shall be cut square the ends internally reamed and threaded the proper length and assembled at all fittings in proper manner so that all joints will be mechanically secure, water tight, and provide electrical continuity. All threaded connections shall be given a coat of pipe joint compound before fitting up.

The ends of field cut joints on non-metallic conduit, except plastic, shall be tapered to conform to factory ends. The sections shall be joined at couplings and fittings by tapping the ends of sections sufficiently to provide water tight joints without over stressing or cracking the fittings. Where non-metallic conduit is joined to metallic conduit, special tapered and threaded non-metallic adaptors shall be used. When fitting-up compound is specified for non-metallic conduit the compound shall be of a type which will remain plastic during assembly and set within a reasonable period thereafter. The compound shall be carefully painted on joints so that excess compound will not intrude on the inner surface of the conduit after assembly.

All junction boxes shall be of sufficient size to provide for proper splicing and packing of all conductors, plus additional space for a future increase of 50% in the number of conductors or conductor size.

All unused openings in boxes and fitting shall be closed by tight metal plates or plugs and all dead ends of conduit, except where provided for drainage, shall be fitted with pipe caps.

All terminal ends of conduit not ending in boxes or condulets shall be fitted with rubber based caps containing the required number and size of holes to tightly fit the conductors running through, or fitted with, standard water tight terminal fittings or pot-heads.

Where an obstruction may have developed in any conduit run it shall be removed, if practicable. If the obstruction is not removed the affected portion of the conduit system shall be removed and replaced with new, clean conduit or, if this cannot be accomplished, an entire new conduit shall be placed around the affected section at a location selected by the Engineer.

All conduit encased in concrete shall be rigidly held in proper position during concrete placement. Non-metallic conduit shall be secured against separation at the joints during concrete placement by being tied to a separate steel rod at least ½ in. in diameter running the full length of the conduit.

Such rod and ties shall be considered as parts of the electrical installation.

Provisions for adequate drainage shall be made in all conduit systems. Horizontal runs shall be slightly pitched and unless completely sealed against moisture. All low points shall be drained.

Conduit shall be adequately supported by sleeves, fixed boxes, hangers, clamps or anchorages placed at intervals not exceeding 5 ft. Anchor bolts which are indicated on the plans as set in concrete shall be placed in the proper location before placing concrete.

Condulets, pull boxes, junction boxes and caps shall be of galvanized cast or malleable iron, of the threaded connection type with cast waterproof covers lined with moisture proof gaskets. The covers of junction boxes which house transformers or cutouts shall be attached to the box by hinges or chains.

Conduit or raceway sleeves shall be placed during construction of the portions of the structures in which they are located. They shall be maintained in a clean condition and protected from damage or obstruction by placing removable plugs or caps until ready for use.

In general, exposed conduit shall not be placed until all adjacent construction work has been completed. Portions of conduit to be encased in masonry, or boxed in between structural members, shall be placed in advance of placing concrete or during assembly of structural members and protected from damage and plugging by use of covers or tight fitting metal caps.

3.2 Electric Manholes, Handholes, Pull Boxes and Junction Boxes

A. General

Electric manholes, handholes, pull and junction boxes shall be built to the lines, grades, dimensions and designs shown on the plans or Standard Drawings with the necessary frames, covers, etc., in accordance with the applicable provisions of Subsection 201: Basins, Manholes and Inlets.

B. Cast in Place Concrete Units

After excavation, all loose material shall be removed before the forms are installed. All conduits, ground rods, pulling irons and reinforcing steel shall be installed rigidly in place before the concrete is placed. After the concrete for the manhole, handhole or pull box is placed, and forms removed, all exposed portions of the concrete shall be neatly finished. Frame castings shall be set according to the requirements of 201.63: Placing Castings.

C. Pre-Cast Concrete Units

The construction methods for pre-cast concrete units shall conform to the relevant provisions of Subsection 901: Cement Concrete, M4.02.14: Precast Units, and the above 801.61: Electric Manholes, Handholes, Pull Boxes and Junction Boxes, Paragraph B.

D. Metallic Units

Metallic pull and junction boxes shall be installed at the approximate locations shown on the plans, or in long conduit runs, they shall not be spaced over 150 ft from each other. It shall be in the option of the Contractor, at their expense, to install additional pull or junction boxes that they may desire to facilitate their work.

Pull or junction boxes installed shall not be of dissimilar metal to the metal conduit used in any one electrical system.

3.3 Foundations

Light standard, lighting load center, signal post, strain pole, signal mast arm and signal control cabinet foundations, shall be constructed with the necessary anchor bolts (supplied under the items listed in Subsection 815: Traffic Control Signals, Subsection 820: Highway Lighting and Subsection 824: Flashing Beacons, Illuminated Warning Signs, and Lighted Barrier Arrows), reinforcing rods, conduit elbows or sweeps, etc., as shown on the Standard Drawings, and in accordance with the applicable requirements of Subsection 901: Cement Concrete.

For core type foundation estimating and bidding purposes, in the absence of boring samples, or the actual determination of the soil properties at the proposed footing location, the Department will accept an assumed soil bearing pressure of 2 ksf for the design of the footing using the Span Wire Assembly Design Chart III of the Departments Standard Drawings. The moments shall be calculated from the data obtained from the relevant traffic control signal plan.

However, the augered foundations shall not be constructed prior to soil classification of the subsurface soil by a qualified firm or person to perform the soil classification, analysis, and footing design.

The actual existing soil conditions shall be determined from boring samples (see Subsection 190: Borings). If the results of the auger boring show that the soil classification requires the use of a Foundation Design Chart that requires a greater depth the foundation shall be constructed according to the requirements of the appropriate chart and payment will be made for the difference in depth under Item 815.98.

Inversely, if it is determined the soil classification permits the use of a Foundation Design Chart that requires a lesser depth, the Department shall be credited for the difference in depth under Item 815.98.

All unsuitable material within the limits of the footing must be removed at the direction of the Engineer (Peat organic material, material that has been dumped, etc.).

The concrete for the footing shall be placed immediately after excavation to prevent water from collecting in the excavated area.

END OF SECTION