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SECTION 22 0500

PLUMBING MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 1. Building service outages.
 2. Electrical requirements for plumbing equipment.
 3. Welding requirements.
 4. Fire safety precautions
 5. Plumbing systems commissioning
 6. Piping materials and installation instructions common to most piping systems.
 7. Transition fittings.
 8. Dielectric fittings.
 9. Escutcheons.
 10. Grout.
 11. Cutting and Patching
 12. Plumbing Demolition
 13. Equipment installation requirements common to equipment sections.
 14. Painting and finishing.
 15. Concrete bases.
 16. Supports and anchorages.

1.3 DEFINITIONS

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

- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
- E. 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.
- F. The following are industry abbreviations for plastic materials:
 - 1. ABS: Acrylonitrile-butadiene-styrene plastic.
 - 2. CPVC: Chlorinated polyvinyl chloride plastic.
 - 3. PE: Polyethylene plastic.
 - 4. PVC: Polyvinyl chloride plastic.
- G. The following are industry abbreviations for rubber materials:
 - 1. EPDM: Ethylene-propylene-diene terpolymer rubber.
 - 2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

- A. Product Data: For the following:
 - 1. Transition fittings.
 - 2. Dielectric fittings.
 - 3. Mechanical sleeve seals.
 - 4. Escutcheons.
- B. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Product Standards:
 - 1. Refer to Division 1.
 - 2. Where products are specified by manufacturer, brand name or catalog number, this establishes the standard of quality and style of the product to be provided under the Contract, unless a change in quality or style is approved by Owner.
 - 3. All Contractor-furnished equipment, including its component parts, shall be the current standard products of the manufacturer in order to insure prompt and continuing service and replacement of parts.
 - 4. Where 2 or more units of the same class of equipment are required, these units shall be the products of a single manufacturer; however, the component parts of the equipment need not be the product of the same manufacturer.
- B. Referenced Standards:
 - 1. The following are names of technical and trade organizations, together with the corresponding acronyms, used in this Specification when citing specific standards published by these organizations:

- a. Air-Conditioning and Refrigeration Institute (ARI)
 - b. American Concrete Institute
 - c. American Conference of Governmental Industrial Hygienists
 - d. American Gas Association (AGA)
 - e. American Institute of Steel Construction
 - f. American National Standards Institute (ANSI)
 - g. American Society of Heating, Refrigeration and Air Conditioning Engineers
 - h. American Society of Mechanical Engineers (ASME)
 - i. American Society for Testing Materials (ASTM)
 - j. American Water Works Association (AWWA)
 - k. American Welding Society
 - l. ANSI Code for Power Piping B31.1
 - m. Hydraulic Institute Standards for Centrifugal, Rotary and Reciprocating Pumps
 - n. Institute of Electrical and Electronic Engineers
 - o. National Bureau of Standards
 - p. National Commercial and Industrial Insulation Standards
 - q. National Electrical Manufacturers Association (NEMA)
 - r. National Electric Code (NEC)
 - s. National Safety Code for Mechanical Refrigeration
 - t. Occupational Safety and Health Organization (OSHA)
 - u. Tubular Exchanger Manufacturers Association (TEMA)
 - v. Underwriters Laboratories (UL)
2. Where a reference standard is cited in this Specification, the subject to which it applies (equipment, material or work) shall be in compliance with the most recent edition of that standard.
 3. None of the above, however, shall be construed as relieving Contractor from complying with any requirement in this Specification that may be in excess of, but not contrary to, the referenced standard.

1.6 BUILDING SERVICE OUTAGES

- A. Service Outage Request: The contractor shall request all building service outages through the owner's representative. The contractor shall provide a minimum notification of 24 hours.

1.7 ELECTRICAL REQUIREMENTS FOR PLUMBING EQUIPMENT

- A. 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.

1.8 WELDING REQUIREMENTS

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

1.9 FIRE SAFETY PRECAUTIONS

- A. A Hot Works Permit is required for any temporary operation that involves open flames or produces heat and/or sparks. Such operations include, but are not limited to, brazing cutting, grinding, soldering, thawing pipe, torch applied roofing, and welding. Before doing any type of open flame or hot works operation, obtain a Hot Works Permit from the customer service representative in the particular zone where the work will be performed.
- B. All grinding, cutting, brazing, sweating, or welding operations carried on in the vicinity of, or accessible to combustible material, shall be adequately protected to make certain that a spark or hot slag does not reach the combustible material and start a fire.
- C. When it is necessary to do grinding, cutting, brazing, sweating or welding close to wood construction in pipe shafts or other locations where combustible materials cannot be removed or adequately protected, employ fireproof blankets and proper fire extinguishers. A helper shall be stationed nearby to guard against sparks and fire.
- D. Whenever combustible material has been exposed to molten metal or hot slag from welding or cutting operations or spatter from electric arc, a fireguard shall be kept at the place of the hot work for at least one hour after completion to make sure that smoldering fires do not start.
- E. When welding or cutting in vertical pipe shaft or floor opening, a fireguard shall examine all floors below the welding or cutting operation. The fireguard shall be kept on duty for at least one hour after completion of work to guard against fires.

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 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 mechanical items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 8 Section "Access Doors and Frames."

1.12 STARTUP/COMMISSIONING

- A. The building plumbing systems shall be commissioned in accordance with the latest edition of the ASHRAE document, "Guideline for Commissioning of Plumbing Systems". Documentation and testing of these systems is required in cooperation with the Commissioning Authority. Project closeout is dependant on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Project Closeout, Section 01700, for substantial completion details. Refer to Section 01810 for detailed commissioning requirements.
- B. For purposes of implementing this guideline, the Commissioning Authority shall be defined as being a member of the University Staff.
- C. The contractor shall provide labor, material, and equipment required to facilitate the commissioning process as well as making adjustments and modifications needed to correct deficiencies in the operation of the equipment.
- D. The contractor shall submit copies of the service tickets to the commissioning authority during the one-year correction period. This step verifies that there are no unresolved deficiencies with the system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

- A. Refer to individual Division 22 piping Sections for special joining materials not listed below.
- B. 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.
- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
- G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- H. Solvent Cements for Joining Plastic Piping:
1. ABS Piping: ASTM D 2235.
 2. CPVC Piping: ASTM F 493.
 3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
 4. PVC to ABS Piping Transition: ASTM D 3138.

2.4 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. Manufacturers:
 - a. Cascade Waterworks Mfg. Co.
 - b. Dresser Industries, Inc.; DMD Div.
 - c. Ford Meter Box Company, Incorporated (The); Pipe Products Div.
 - d. JCM Industries.
 - e. Smith-Blair, Inc.
 - f. Viking Johnson.
 - ~~2. Underground Piping NPS 1 1/2 and Smaller: Manufactured fitting or coupling.~~
 - ~~3. Underground Piping NPS 2 and Larger: AWWA C219, metal sleeve type coupling.~~

4. Aboveground Pressure Piping: Pipe fitting.
 - B. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
 1. Manufacturers:
 - a. Eslon Thermoplastics.
 - 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.
 1. Manufacturers:
 - a. Thompson Plastics, Inc.
 - D. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC and PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.
 1. Manufacturers:
 - a. NIBCO INC.
 - b. NIBCO, Inc.; Chemtrol Div.
 - 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.
 1. Manufacturers:
 - a. Cascade Waterworks Mfg. Co.
 - b. Fernco, Inc.
 - c. Mission Rubber Company.
 - d. Plastic Oddities, Inc.

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 deg F.
 1. Manufacturers:
 - a. Capitol Manufacturing Co.
 - b. Central Plastics Company.
 - c. Eclipse, Inc.
 - d. Epco Sales, Inc.

- e. Hart Industries, International, Inc.
 - f. Watts Industries, Inc.; Water Products Div.
 - g. Zurn Industries, Inc.; Wilkins Div.
- D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
- 1. Manufacturers:
 - a. Capitol Manufacturing Co.
 - b. Central Plastics Company.
 - c. Epco Sales, Inc.
 - d. Watts Industries, Inc.; Water Products Div.
- 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. Manufacturers:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Central Plastics Company.
 - d. Pipeline Seal and Insulator, Inc.
 - 2. 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 deg F.
- 1. Manufacturers:
 - a. Calpico, Inc.
 - b. Lochinvar Corp.
- 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 deg F.
- 1. Manufacturers:
 - a. Perfection Corp.
 - b. Precision Plumbing Products, Inc.
 - c. Sioux Chief Manufacturing Co., Inc.
 - d. Victaulic Co. of America.

2.6 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
- C. One-Piece, Cast-Brass Type: With set screw.
 - 1. Finish: Polished chrome-plated and rough brass.
- D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
 - 1. Finish: Polished chrome-plated and rough brass.
- E. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.
- F. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw or spring clips, and chrome-plated finish.
- G. One-Piece, Floor-Plate Type: Cast-iron floor plate.
- H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

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.

PART 3 - EXECUTION

3.1 PLUMBING DEMOLITION

- A. Refer to Division 1 Section "Cutting and Patching" and Division 2 Section "Selective Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed.
 - 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - 2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
 - 3. Equipment to Be Removed: Disconnect and cap services and remove equipment.

4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 CUTTING AND PATCHING

- A. General: Comply with Division 1 Section "Execution" for general cutting and patching procedures.
- B. Core drilling, cutting and patching, required for the installation of plumbing equipment as shown on the drawings and/or specified in Division 22 shall be the responsibility of this Contractor except where specifically stated otherwise. Only workers that are experienced, skilled, and licensed for the particular type of work involved, shall perform cutting and patching.
1. Hanger inserts and pipe sleeves to be incorporated into the general building construction shall be furnished and installed by Contractor in ample time to avoid delaying the work of other trades or causing unnecessary cutting and patching work. Should any cutting be required to set inserts or sleeves, it shall be performed by Contractor using proper skilled tradesmen for the material involved, such as a bricklayer for masonry wall patching, etc.
 2. Core drilling shall be used where practical. Reasonable care shall be exercised during cutting to keep patching at a minimum.
 3. Under no circumstances shall any cutting or burning of the structural parts of the building be undertaken without authority of Engineer.
 4. When identical patching materials are not available for exteriors of historic buildings, submit alternate materials for review with the University Architects Office.

3.3 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 22 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 Coordination Drawings.
- 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 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. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 - 1. New and existing piping to remain: Use the following
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
 - c. Insulated Piping: One-piece, stamped-steel type with spring clips.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
 - e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.
 - f. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed or exposed-rivet hinge and set screw.
 - g. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw.
 - h. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type. Install sleeves for pipes passing through concrete and masonry walls, gypsum board partitions, and concrete floor and roof slabs.
- M. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 7 Section "Firestopping" for materials.
- N. Verify final equipment locations for roughing-in.
- O. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.4 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.
- 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. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. 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.
- 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-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 3. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
 - 4. PVC Nonpressure Piping: Join according to ASTM D 2855.
- I. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
- J. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

3.5 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.

3.6 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.

3.7 PAINTING

- A. Piping and other equipment that is furnished and installed under Division 22 and is exposed in finished spaces will be completed under Division 9 of the Specifications.
- B. Painting of exposed piping, ducts and other equipment in equipment spaces and accessible tunnels, crawl spaces, shafts, and other unfinished spaces, including painting of canvas jacketed pipe insulation, shall be completed by this Contractor.
- C. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.8 CONCRETE BASES

- A. The concrete work, including formwork and setting of anchor bolts and sleeves, is specified in other sections. Contractor shall be responsible for providing an accurate drawing of each equipment base required with the location of each anchor bolt properly dimensioned, and before the concrete is placed, the Contractor shall check and approve the formwork and placement of the anchor bolts.
- B. Contractor shall furnish anchor bolt and sleeve assemblies for all concrete equipment bases required in connection with the work under this Contract. Anchor bolts and sleeves shall be of approved material, size and shape. Inside diameter of sleeves shall be at least 2-1/2 times the bolt diameter.
- C. After Contractor has set and leveled the equipment, he shall be responsible for furnishing and proper placing of non-shrink grout for each base with 1 inch nominal thickness between the top of the concrete base and the bottom of the equipment base. Leveling of equipment and grouting shall be in strict accordance with manufacturer's recommendations and instructions of Owner's Construction Representative.

3.9 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 5 Section "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.10 GROUTING

- A. Mix and install grout for mechanical 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 22 0500

SECTION 22 05 17

SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Sleeves.
 - 2. Sleeve-seal systems.

1.3 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

2.2 SLEEVE-SEAL SYSTEMS

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

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 annular clear space between piping and concrete slabs and walls as required by sleeve-seal system.
 - 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 Division 07 Section "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 Division 07 Section "Penetration Firestopping."

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

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

END OF SECTION 22 0517

SECTION 22 05 19

PLUMBING METERS AND GAGES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes flow meters and gages for plumbing systems.

1.2 SUBMITTALS

- A. Product Data: Include scale ranges, ratings, and calibrated performance curves for each meter, gage, fitting, specialty, and accessory specified. Include interconnecting wiring diagrams.
- B. Shop Drawings: Include schedule indicating manufacturer's number, scale range, fittings, and location for each meter and gage.
- C. Product Certificates: Signed by manufacturers of meters and gages certifying accuracies under specified operating conditions and compliance with specified requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified:
1. Liquid-in-Glass Thermometers:
 - a. Dresser Industries, Inc.; Instrument Div.; Weksler Instruments Operating Unit.
 - b. Ernst Gage Co.
 - c. Marsh Bellofram.
 - d. Palmer Instruments, Inc.
 - e. Trerice: H. O. Trerice Co.
 - f. Weiss Instruments, Inc.
 - g. Winter's Thermogauges, Inc.
 2. Pressure Gages:
 - a. AMETEK, Inc.; U.S. Gauge Div.
 - b. Dresser Industries, Inc.; Instrument Div.; Ashcroft Commercial Sales Operation.
 - c. Dresser Industries, Inc.; Instrument Div.; Weksler Instruments Operating Unit.
 - d. Trerice: H. O. Trerice Co.
 - e. Weiss Instruments, Inc.

- f. WIKA Instruments Corp.
- 3. Test Plugs:
 - a. Peterson Equipment Co., Inc.

2.2 THERMOMETERS, GENERAL

- A. Scale Range: Temperature ranges for services listed are as follows:
 - 1. Domestic Water: 0 to 100 deg F, with 2-degree scale divisions.
 - 2. Domestic water: 0 to 200 deg F
 - 3. Accuracy: Plus or minus 1 percent of range span or plus or minus one scale division to maximum of 1.5 percent of range span.

2.3 LIQUID-IN-GLASS THERMOMETERS

- A. Description: ASTM E 1.
- B. Case: Die cast and aluminum finished in baked-epoxy enamel, glass front, spring secured, 9 inches long.
- C. Adjustable Joint: Finish to match case, 180-degree adjustment in vertical plane, 360-degree adjustment in horizontal plane, with locking device.
- D. Tube: Red or blue reading, organic-liquid filled with magnifying lens.
- E. Scale: Satin-faced nonreflective aluminum with permanently etched markings.
- F. Stem: Copper-plated steel, aluminum, or brass for separable socket; of length to suit installation.

2.4 THERMOMETER WELLS

- A. Description: Fitting with protective well for installation in threaded pipe fitting to hold thermometer.
 - 1. Material: Stainless steel, for use in steel piping.
 - 2. Extension-Neck Length: Nominal thickness of 2 inches, but not less than thickness of insulation. Omit extension neck for wells for piping not insulated.
 - 3. Insertion Length: To extend to center of pipe.
 - 4. Heat-Transfer Fluid: As per manufacturer's written instructions.

2.5 PRESSURE GAGES

- A. Description: ASME B40.1, phosphor-bronze bourdon-tube type with bottom connection; dry type, unless liquid-filled-case type is indicated.
- B. Case: Stainless steel with 6-inch diameter, glass lens.
- C. Connector: Brass, NPS 1/4.

- D. Scale: White-coated aluminum with permanently etched markings.
- E. Accuracy: Grade A, plus or minus 1 percent of middle 50 percent of scale.
- F. Scale Range: Pressure ranges for services listed are as follows:
 - 1. Domestic and Laboratory Water: 0 to 150 psi, with 2 psi scale divisions.
 - 2. Accuracy: Plus or minus 1 percent of range span or plus or minus one scale division to maximum of 1.5 percent of range span.

2.6 PRESSURE-GAGE FITTINGS

- A. Valves for Domestic and Laboratory Water: NPS 1/4 brass or stainless-steel needle or ball type.

2.7 TEST PLUGS

- A. Description: Nickel-plated, brass-body test plug in NPS 1/2 fitting.
- B. Body: Length as required to extend beyond insulation.
- C. Pressure Rating: 500 psig minimum.
- D. Core Inserts: Two self-sealing valves, suitable for inserting 1/8-inch OD probe from dial-type thermometer or pressure gage.
- E. Core Material for Air and Water: Minus 30 to plus 275 deg F, ethylene-propylene-diene terpolymer rubber.
- F. Test-Plug Cap: Gasketed and threaded cap, with retention chain or strap.

PART 3 - EXECUTION

3.1 METER AND GAGE INSTALLATION, GENERAL

- A. Install meters, gages, and accessories according to manufacturer's written instructions for applications where used.

3.2 THERMOMETER INSTALLATION

- A. Install thermometers and adjust vertical and tilted positions.
- B. Install in the following locations:
 - 1. Where indicated on drawings.
- C. Install thermometer wells in vertical position in piping tees where test thermometers are indicated.
 - 1. Install with stem extending to center of pipe.
 - 2. Fill wells with oil or graphite and secure caps.

3.3 PRESSURE-GAGE INSTALLATION

- A. Install pressure gages in piping tees with pressure-gage valve located on pipe at most readable position.
- B. Install pressure-gage ball or needle valve and snubber in piping to pressure gages.
- C. Install in the following locations:
 - 1. Where indicated on drawings.

3.4 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties. The following are specific connection requirements:
 - 1. Install meters and gages adjacent to machines and equipment to allow service and maintenance.

3.5 ADJUSTING AND CLEANING

- A. Calibrate meters according to manufacturer's written instructions, after installation.
- B. Adjust faces of meters and gages to proper angle for best visibility.
- C. Clean windows of meters and gages and clean factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touch-up paint.

END OF SECTION 22 0519

SECTION 22 0523

PLUMBING VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following general-duty valves:
 - 1. Copper-alloy ball valves.
 - 2. Ferrous-alloy ball valves.
 - 3. Ferrous-alloy butterfly valves.
 - 4. Bronze check valves.
 - 5. Cast steel swing check valves.
 - 6. Spring-loaded, lift-disc check valves.
 - 7. Bronze gate valves.
 - 8. Cast-iron gate valves.
- B. Related Sections include the following:
 - 1. Division 22 Section "Plumbing Identification" for valve tags and charts.
 - 2. Division 22 piping Sections for specialty valves applicable to those Sections only.

1.3 DEFINITIONS

- A. The following are standard abbreviations for valves:
 - 1. CWP: Cold working pressure.
 - 2. EPDM: Ethylene-propylene-diene terpolymer rubber.
 - 3. NBR: Acrylonitrile-butadiene rubber.
 - 4. PTFE: Polytetrafluoroethylene plastic.
 - 5. SWP: Steam working pressure.
 - 6. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS

- A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its

application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

1.5 QUALITY ASSURANCE

- A. ASME Compliance: ASME B31.1 for power piping valves and ASME B31.9 for building services piping valves.
 - 1. Exceptions: Domestic hot- and cold-water, sanitary waste, and storm drainage piping valves unless referenced.
- B. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

1.6 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, and globe valves closed to prevent rattling.
 - 4. Set ball and plug valves open to minimize exposure of functional surfaces.
 - 5. Set butterfly valves closed or slightly open.
 - 6. 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 VALVES, GENERAL

- A. Refer to Part 3 "Valve Applications" Article for applications of valves.
- B. Bronze Valves: NPS 2 and smaller with threaded ends, unless otherwise indicated.
- C. Ferrous Valves: NPS 2-1/2 and larger with flanged 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 pipe, unless otherwise indicated.
- F. Valve Actuators:

1. Chainwheel: For attachment to valves, of size and mounting height, as indicated in the "Valve Installation" Article in Part 3.
 2. Gear Drive: For quarter-turn valves NPS 8 and larger.
 3. Handwheel: For valves other than quarter-turn types.
 4. Lever Handle: For quarter-turn valves NPS 6 and smaller, except plug valves.
 5. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug head.
- G. Extended Valve Stems: On insulated valves.
- H. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.
- I. Valve Grooved Ends: AWWA C606.
1. Solder Joint: With sockets according to ASME B16.18.
 - a. Caution: Use solder with melting point below 840 deg F for angle, check, gate, and globe valves; below 421 deg F for ball valves.
 2. Threaded: With threads according to ASME B1.20.1.
- J. Valve Bypass and Drain Connections: MSS SP-45.

2.2 GATE VALVES

- A. Manufacturers:
1. Subject to compliance with requirements, provide products by the manufacturers specified.
 - a. Bonney Forge
 - b. Crane Company; Valves and Fitting Division.
 - c. Hammond Valve Corporation.
 - d. Milwaukee Valve Company, Inc.
 - e. NIBCO INC.
 - f. Vogt Valves
- B. Valves used for potable water and non-potable water shall be the following.
1. NPS 2 and Smaller: MSS SP-80, Class 150 (150 psig SWP, 300 psig CWP), ASTM B 62 cast bronze body with bronze union ring bonnet, rising stem, solid bronze wedge, with carbon steel or malleable-iron hand wheel, and threaded ends.
 2. NPS 2-1/2 and Larger: MSS SP-70, ANSI Class 150, ASTM A 216 cast-steel body with bolted bonnet, rising stem, outside screw and yoke, solid wedge, 2-piece packing gland assembly, with carbon steel hand wheel, and flanged end connections.

3. NPS 4: MSS SP-70, ANSI Class 125, ASTM A 126 Class B cast-iron body with bolted bonnet, rising stem, outside screw and yoke, solid wedge, 2-piece packing gland assembly, with carbon steel hand wheel, and flanged end or threaded connections.

2.3 BUTTERFLY VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified
 1. Butterfly valves for water service:
 - a. Bray International, Inc.
 - b. Crane Company; Valves and Fitting Division.
 - c. Hammond Valve Corporation.
 - d. Milwaukee Valve Company, Inc.
 - e. Mueller Steam Specialty.
 - f. NIBCO INC.
 - g. Watts Industries, Inc.; Water Products Div.
- B. Valves used for potable and non-potable water shall be the following.
 1. NPS 2-1/2 and Larger: MSS SP-67, 250 psig CWP rating, ASTM A 126 Class B cast iron body with 316 stainless steel shaft and disc, one or two piece stem, field replaceable EPDM seat and seals, extended neck, full lug style with ANSI Class 125 or 150 compatible flanges. Valve seat shall be bubble tight and suitable for 200-psig dead end service.
 - a. Operator for Sizes 2-1/2 Inches to 6 Inches: Standard lever handle with 10-position stop plate and memory stop. Handle shall be pad lockable where installed in areas accessible to the public.
 - b. Operator for Sizes 8 Inches to 24 Inches: Weatherproof gear operator with position indicator. Operator shall be lockable where installed in areas accessible to the public.

2.4 BALL VALVES

- A. Manufacturers:
 1. Subject to compliance with requirements, provide products by the manufacturers specified:
 - a. American Valve, Inc.
 - b. Conbraco Industries, Inc.; Apollo Division.
 - c. Hammond Valve Corporation.
 - d. Milwaukee Valve Company, Inc.
 - e. NIBCO Inc.
 - f. Stockham Valves & Fittings, Inc.

- B. Valves used for potable water and non-potable water shall be the following.
1. NPS 2 and Smaller: MSS SP-110, Class 150 (150 psig SWP, 600 psig CWP), ASTM B 584 cast bronze body and packing nut, with full port, two-piece construction, 316 stainless steel ball and blowout proof stem, packing nut design, reinforced Teflon seats and seals, ferrous alloy vinyl covered handle, and threaded end connections. Provide memory stop where used in balancing applications. Handle shall be pad lockable where installed in areas accessible to the public.
 2. NPS 2-1/2 through NPS 6: MSS SP-72, Class 125 (125 psig SWP, 200 psig CWP), ASTM A 126 Class B cast iron body with full port, two-piece bolted construction, cast iron Teflon fused ball, stainless steel blowout proof stem, reinforced Teflon seats and seals, steel rubber covered handle, and flanged end connections. Provide memory stop where used in balancing applications. Handle shall be pad lockable where installed in areas accessible to the public.

2.5 CHECK VALVES

- A. Manufacturers:
1. Subject to compliance with requirements, provide products by the manufacturers specified:
 - a. American Valve, Inc.
 - b. Cincinnati Valve Co.
 - c. Crane Co.; Crane Valve Group; Crane Valves.
 - d. Crane Co.; Crane Valve Group; Jenkins Valves.
 - e. Crane Co.; Crane Valve Group; Stockham Div.
 - f. Grinnell Corporation.
 - g. Hammond Valve.
 - h. Kitz Corporation of America.
 - i. Legend Valve & Fitting, Inc.
 - j. Milwaukee Valve Company.
 - k. NIBCO INC.
 - l. Powell, Wm. Co.
 - m. Red-White Valve Corp.
 - n. Walworth Co.
 - o. Watts Industries, Inc.; Water Products Div.
- B. Valves used for potable water and non-potable water shall be the following:
1. Swing Check Valves, NPS 2 and Smaller: MSS SP-80, Class 150 (150 psig SWP, 300 psig CWP), ASTM B 62 cast bronze body with threaded bonnet, full port construction, with Teflon disc, bronze seat, and threaded end connections.

2. Spring Check Valves, NPS 2 and Smaller: Class 150 (150 psig SWP, 300 psig CWP), ASTM B 62 cast bronze body, two piece construction, with EPDM seal, stainless steel stem and disc, and threaded end connections.
3. Swing Check Valves, NPS 2-1/2 and Larger: MSS SP-71, ANSI Class 150, ASTM A 216 cast-steel body with bolted bonnet, replaceable composition disc, and flanged end connections.
4. Spring Check Valves, NPS 2-1/2 and Larger: ANSI Class 150, ASTM A 126 Class B cast-iron body, with stainless steel trim and spring, wafer style with ANSI Class 125 or 150 compatible casting.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.
 1. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. 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.
- C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- D. Examine threads on valve and mating pipe for form and cleanliness.
- E. 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.
- F. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE APPLICATIONS

- A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:
 1. Shutoff Service: Ball, butterfly, or gate valves.
 2. Throttling Service: Ball, butterfly, or globe valves.
 3. Pump Discharge: Spring-loaded, lift-disc check valves.
- B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.

3.3 VALVE INSTALLATION

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

- B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- C. Locate valves for easy access and provide separate support where necessary.
- D. Install valves in horizontal piping with stem at or above center of pipe.
- E. Install valves in position to allow full stem movement.
- F. Install check valves for proper direction of flow and as follows:
 - 1. Swing Check Valves: In horizontal position with hinge pin level.
 - 2. Spring-Loaded, Lift-Disc Check Valves: In horizontal or vertical position, between flanges.

3.4 JOINT CONSTRUCTION

- A. Refer to Division 22 Section "Plumbing Materials and Methods" for basic piping joint construction.
- B. Grooved Joints: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.
- C. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.5 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.

END OF SECTION 22 0523

SECTION 22 05 29

PLUMBING HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes hangers and supports for mechanical system piping and equipment.
- B. Related Sections include the following:
 - 1. Division 5 Section "Metal Fabrications" for materials for attaching hangers and supports to building structure.

1.3 DEFINITIONS

- A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry.
- B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

- A. Design channel support systems for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
- B. Design heavy-duty trapezes for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

1.5 SUBMITTALS

- A. Product Data: For each type of pipe hanger, channel support system component, and thermal-hanger shield insert indicated.
- B. Welding Certificates: Copies of certificates for welding procedures and operators.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Pipe Hangers:
 - a. Globe Pipe Hanger Products, Inc.
 - b. Grinnell Corp.
 - c. Michigan Hanger Co., Inc.
 - d. National Pipe Hanger Corp.
 - e. PHD Manufacturing, Inc.
 - f. Piping Technology & Products, Inc.
2. Channel Support Systems:
 - a. Grinnell Corp.; Power-Strut Unit.
 - b. Michigan Hanger Co., Inc.; O-Strut Div.
 - c. National Pipe Hanger Corp.
 - d. Thomas & Betts Corp.
 - e. Unistrut Corp.
3. Thermal-Hanger Shield Inserts:
 - a. Carpenter & Patterson, Inc.
 - b. Michigan Hanger Co., Inc.
 - c. PHS Industries, Inc.
 - d. Pipe Shields, Inc.
4. Powder-Actuated Fastener Systems:
 - a. Gunnebo Fastening Corp.
 - b. Hilti, Inc.
 - c. ITW Ramset/Red Head.
 - d. Masterset Fastening Systems, Inc.
5. Non-Metallic Strut, Pipe Hangers & Support Systems:
 - a. Aickinstrut; AU Allied Tube & Conduit Company.
 - b. Champion Fiberglass, Inc.
 - c. Cooper B-Line, Inc.

2.2 MANUFACTURED UNITS

- A. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated components. Refer to "Hanger and Support Applications" Article in Part 3 for where to use specific hanger and support types.
 1. Galvanized, Metallic Coatings: For piping and equipment that will not have field-applied finish.
 2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

- B. Thermal-Hanger Shield Inserts: 100-psi minimum compressive-strength insulation, encased in sheet metal shield.
 - 1. Material for Cold Piping: ASTM C 552, Type I cellular glass or water-repellent-treated, ASTM C 533, Type I calcium silicate with vapor barrier.
 - 2. Material for Hot Piping: ASTM C 552, Type I cellular glass or water-repellent-treated, ASTM C 533, Type I calcium silicate.
 - 3. For Trapeze or Clamped System: Insert and shield cover entire circumference of pipe.
 - 4. For Clevis or Band Hanger: Insert and shield cover lower 180 degrees of pipe.
 - 5. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.3 MISCELLANEOUS MATERIALS

- A. Powder-Actuated Drive-Pin Fasteners: Powder-actuated-type, drive-pin attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.
- C. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.
- D. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged, nonshrink and nonmetallic, dry, hydraulic-cement grout.
 - 1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.
 - 2. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 3. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger requirements are specified in Sections specifying equipment and systems.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Specification Sections.
- C. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification 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 cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.

3. 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.
 4. Adjustable Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
 5. Adjustable Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
 6. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
 7. Adjustable Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2 (DN15 to DN50).
 8. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
 9. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
 10. U-Bolts (MSS Type 24): For support of heavy pipe, NPS 1/2 to NPS 30.
 11. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
- D. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Specification 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.
- E. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- F. Minimum Hanger-Rod Diameters: Unless otherwise indicated and except as specified in piping system Specification Sections, the minimum hanger rod diameters for piping supports shall be as followings:
1. For pipe sizes, up to NPS 2, use 3/8 inch.
 2. For pipe sizes, from NPS 2-1/2 to NPS 3-1/2, use 1/2 inch.

3. For pipe sizes, from NPS 4 to NPS 5, use 5/8 inch.
 4. For pipe size NPS 6, use 3/4 inch.
 5. For pipe sizes, from NPS 8 to NPS 12, use 7/8 inch.
- G. Building Attachments: Unless otherwise indicated and except as specified in piping system Specification 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 head room is limited.
- H. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Specification 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 by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe, 360-degree insert of high-density, 100-psi minimum compressive-strength, water-repellent-treated calcium silicate or cellular-glass pipe insulation, same thickness as adjoining insulation with vapor barrier and encased in 360-degree sheet metal shield.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Pipe Hanger and Support 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. Vertical-Piping Clamp Installation: Unless otherwise indicated and except as specified in piping system Specification Sections, install riser clamps to support vertical risers at every floor.
- C. Channel Support System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems.
 1. Field assemble and install according to manufacturer's written instructions.
- D. Heavy-Duty Steel Trapeze Installation: Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated, heavy-duty trapezes.
 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, steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.
- E. Install building attachments within concrete slabs or attach to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, and expansion joints, 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.
- F. Install powder-actuated drive-pin fasteners 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.
- G. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- H. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

- I. Install hangers and supports to allow controlled thermal 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.
- 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 so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping," is not exceeded.
- L. 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.
 - 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 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.
 - 5. Insert Material: Length at least as long as protective shield.
 - 6. 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 above or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

3.4 METAL FABRICATION

- A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes 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 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 contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

- A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

3.6 PAINTING

- A. Touching Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9 Section "Painting."
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 22 0529

SECTION 22 05 53

PLUMBING IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following mechanical identification materials and their installation:
 - 1. Equipment nameplates.
 - 2. Equipment markers.
 - 3. Equipment signs.
 - 4. Access panel and door markers.
 - 5. Pipe markers.
 - 6. Stencils.
 - 7. Valve tags.
 - 8. Valve schedules.
 - 9. Warning tags.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Valve numbering scheme.
- C. Valve Schedules: For each piping system. Furnish extra copies (in addition to mounted copies) to include in maintenance manuals.

1.4 QUALITY ASSURANCE

- A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

1.5 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 location of access panels and doors.

- C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION DEVICES

- A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.
1. Data:
 - a. Manufacturer, product name, model number, and serial number.
 - b. Capacity, operating and power characteristics, and essential data.
 - c. Labels of tested compliances.
 2. Location: Accessible and visible.
 3. Fasteners: As required to mount on equipment.
- B. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.
1. Terminology: Match schedules as closely as possible.
 2. Data:
 - a. Name and plan number.
 - b. Equipment service.
 - c. Design capacity.
 - d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.
 3. Size: 2-1/2 by 4 inches for control devices and valves; 4-1/2 by 6 inches for equipment.
- C. Equipment Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.
1. Data: Instructions for operation of equipment and for safety procedures.
 2. Engraving: Manufacturer's standard letter style, of sizes and with terms to match equipment identification.
 3. Thickness: 1/16 inch for units up to 20 sq. in. or 8 inches in length, and 1/8 inch for larger units.
 4. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.
- D. Access Panel and Door Markers: 1/16-inch- thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch center hole for attachment.

1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.2 PIPING IDENTIFICATION DEVICES

- A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.
 1. Colors: Comply with Table 2.2a Piping Identification Application Schedule below. If service type is not listed, colors shall comply ASME A13.1.
 2. Lettering: Use piping system terms indicated in table below.
 3. Lettering Size: Letters shall have a minimum height of 1 inch.
 4. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers extending 360 degrees around pipe at each location.
 5. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type pipe markers at least three times letter height and of length required for label.
 6. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow. Arrow color shall be black.
- B. Pretensioned Pipe Markers: Precoiled semirigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.
- C. Shaped Pipe Markers: Preformed semirigid plastic formed to partially cover circumference of pipe and to attach to pipe with mechanical fasteners that do not penetrate insulation vapor barrier.
- D. Self-Adhesive Pipe Markers: Plastic with pressure-sensitive, permanent-type, self-adhesive back.
- E. Plastic Tape: Continuously printed, vinyl tape at least 3 mils thick with pressure-sensitive, permanent-type, self-adhesive back.
 1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: 3/4 inch minimum.
 2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

Table 2.2a Piping Identification Application Schedule:

Service	Band	Background Letters	Legend
Cold Water (Potable)	Green	Black	POT. C.W.
Domestic Hot Water	Green	Black	POT. H.W.
Domestic Re-circulated Hot Water	Green	Black	POT. C.H.W.
Sanitary Sewer	None	Green	SAN.
Sanitary Vent	Green	Black	SAN. VT
Sanitary Waste	Green	Black	SAN

2.3 STENCILS

- A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door markers, equipment markers, equipment signs, and similar operational instructions.
1. Stencil Paint: Exterior, gloss, acrylic enamel black, unless otherwise indicated. Paint may be in pressurized spray-can form.
 2. Identification Paint: Exterior, acrylic enamel in colors according to ASME A13.1, unless otherwise indicated.

2.4 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers. Provide 5/32-inch hole for fastener.
1. Material: 19 gauge brass or 0.032 inch aluminum.
 2. Valve-Tag Fasteners: Brass "S" hooks or beaded chain.

2.5 VALVE SCHEDULES

- A. Valve Schedules: For each piping system, on standard-size bond paper. Tabulate valve number (corresponding to valve numbers on drawings and control diagrams and sequences of operation), piping system, system abbreviation (as shown on valve tag), location of valve (room or space corresponding to room numbers on architectural floor plans), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
1. Valve-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.
 2. Frame: Finished hardwood.
 3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

2.6 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 APPLICATIONS, GENERAL

- A. Products specified are for applications referenced in other Division 22 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.2 EQUIPMENT IDENTIFICATION

- A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:
1. Pumps, compressors and similar motor-driven units.
 2. Heat exchangers, coils, evaporators and similar equipment.
- B. Install equipment markers with permanent adhesive on or near each major item of mechanical equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.
1. Letter Size: Minimum 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.
 2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
- C. Locate markers where accessible and visible. Include markers for the following general categories of equipment:
- a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
 - b. Meters, gages, thermometers, and similar units.
 - c. Fuel-burning units, water heaters and stills.
 - d. Pumps, compressors, and similar motor-driven units.
 - e. Heat exchangers, coils, evaporators, cooling towers, and similar equipment.
 - f. Tanks and pressure vessels.
 - g. Strainers, filters, humidifiers, water-treatment systems, and similar equipment.
- D. Stenciled Equipment Marker Option: Stenciled markers may be provided instead of laminated-plastic equipment markers, at Installer's option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.

- E. Install equipment signs with screws or permanent adhesive on or near each major item of mechanical equipment. Locate signs where accessible and visible.
1. Identify mechanical equipment with equipment markers in the following color codes:
 - a. Green: For cooling equipment and components.
 - b. Yellow: For heating equipment and components.
 2. Letter Size: Minimum 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.
 3. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
 4. Include signs for the following general categories of equipment:
 - a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
 - b. Fuel-burning units, including water heaters and stills.
 - c. Pumps, compressors and similar motor-driven units.
 - d. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
 - e. Tanks and pressure vessels.
 - f. Strainers, filters, humidifiers, water-treatment systems, and similar equipment.
- F. Stenciled Equipment Sign Option: Stenciled signs may be provided instead of laminated-plastic equipment signs, at Installer's option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.
- G. Install access panel markers with screws on equipment access panels.

3.3 PIPING IDENTIFICATION

- A. Install manufactured pipe markers indicating service on each piping system. Install with black flow indication arrows showing direction of flow.
1. Pipes with OD, Including Insulation, Less Than 6 Inches: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 1-1/2 inches wide, lapped at least 1-1/2 inches at both ends of pipe marker, and covering full circumference of pipe.
 2. Pipes with OD, Including Insulation, 6 Inches and Larger: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 1-1/2 inches wide, lapped at least 3 inches at both ends of pipe marker, and covering full circumference of pipe.

- B. Stenciled Pipe Marker Option: Stenciled markers may be provided instead of manufactured pipe markers, at Installer's option. Install stenciled pipe markers with painted, color-coded bands or rectangles on each piping system.
 - 1. Identification Paint: Use for contrasting background.
 - 2. Stencil Paint: Use for pipe marking.
- C. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed 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 nonaccessible 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. Spaced at maximum intervals of 20 feet and at every change in direction.
 - 8. On piping above removable acoustical ceilings. Omit intermediately spaced markers.

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; plumbing fixture supply stops; 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:
 - 1. Valve-Tag Size and Shape:
 - a. Cold Water: 1-1/2 inches square.
 - b. Hot Water: 1-1/2 inches square.
 - 2. Valve-Tag Color:
 - a. Cold Water: Blue.
 - b. Hot Water: Red.
 - 3. Letter Color:
 - a. Cold Water: White.
 - b. Hot Water: White.

3.5 VALVE-SCHEDULE INSTALLATION

- A. Mount valve schedule on wall in accessible location in each major equipment room.

3.6 WARNING-TAG INSTALLATION

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

3.7 ADJUSTING

- A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.8 CLEANING

- A. Clean faces of mechanical identification devices and glass frames of valve schedules.

END OF SECTION 22 0553

SECTION 22 0719

PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes preformed, rigid and flexible pipe insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds for new piping.
- B. This section also includes re-insulation of asbestos abated piping. Refer to asbestos abatement drawings for scope of re-insulation work.
- C. Related Sections include the following:
 - 1. Division 7 Section "Firestopping" for firestopping materials and requirements for penetrations through fire and smoke barriers.
 - 2. Division 22 0716 Section "Plumbing Equipment Insulation" for insulation materials and application for pumps, tanks, hydronic specialties, and other equipment.
 - 3. Division 22 0716 Section "Plumbing Hangers and Supports" for pipe insulation shields and protection saddles.

1.3 SUBMITTALS

- A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.
- 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.
- C. Installer Certificates: Signed by the Contractor certifying that installers comply with requirements.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.
- B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, NFPA 255 and UL 723, by a testing

and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 22 Section "Hangers and Supports."
- B. Coordinate clearance requirements with piping Installer for insulation application.

1.7 SCHEDULING

- A. Schedule insulation application after testing piping systems. Insulation application may begin on segments of piping that have satisfactory test results.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Mineral-Fiber/Mineral Wool Insulation:
 - a. CertainTeed Manson.
 - b. Knauf FiberGlass GmbH.
 - c. Owens-Corning Fiberglas Corp.
 - d. Schuller International, Inc.

2.2 INSULATION MATERIALS

- A. Mineral-Fiber Insulation: Glass fibers bonded with a thermosetting resin complying with the following:
 1. Preformed Pipe Insulation: Comply with ASTM C 547, Type 1, with factory-applied, all-purpose, vapor-retarder jacket.
 2. Blanket Insulation: Comply with ASTM C 553, Type II, without facing.
 3. Fire-Resistant Adhesive: Comply with MIL-A-3316C in the following classes and grades:

- a. Class 1, Grade A for bonding glass cloth and tape to unfaced glass-fiber insulation, for sealing edges of glass-fiber insulation, and for bonding lagging cloth to unfaced glass-fiber insulation.
 - b. Class 2, Grade A for bonding glass-fiber insulation to metal surfaces.
 4. Vapor-Retarder Mastics: Fire- and water-resistant, vapor-retarder mastic for indoor applications. Comply with MIL-C-19565C, Type II.
 5. Mineral-Fiber Insulating Cements: Comply with ASTM C 195.
 6. Expanded or Exfoliated Vermiculite Insulating Cements: Comply with ASTM C 196.
 7. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.
- B. Mineral-Fiber (Fiberglass) Insulation: Glass fibers bonded with a thermosetting resin complying with the following:
1. Preformed Pipe Insulation: Comply with ASTM C 547, Type I, (850 °F), minimum density 3 lb/ft³, with factory-applied, 11 oz canvas jacket.
 2. Fire-Resistant Adhesive: Comply with MIL-A-3316C in the following classes and grades:
 - a. Class 1, Grade A for bonding glass cloth and tape to unfaced glass-fiber insulation, for sealing edges of glass-fiber insulation, and for bonding lagging cloth to unfaced glass-fiber insulation.
 - b. Class 2, Grade A for bonding glass-fiber insulation to metal surfaces.
 3. Vapor-Retarder Mastics: Fire- and water-resistant, vapor-retarder mastic for indoor applications. Comply with MIL-C-19565C, Type II.
 4. Mineral-Fiber Insulating Cements: Comply with ASTM C 195.
 5. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.
- C. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

2.3 FIELD-APPLIED JACKETS

- A. General: ASTM C 921, Type 1, unless otherwise indicated.
- B. Foil and Paper Jacket: Laminated, glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil.
- C. PVC Jacket: High-impact, ultraviolet-resistant PVC; 30 mils thick on 3" and larger, 20 mils thick on piping smaller than 3"; roll stock ready for shop or field cutting and forming.
 1. Adhesive: As recommended by insulation material manufacturer.
 2. PVC Jacket Color: White or gray.

- D. Heavy PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 30-mil-thick, high-impact, ultraviolet-resistant PVC.
 - 1. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.
 - 2. Adhesive: As recommended by insulation material manufacturer.

2.4 ACCESSORIES AND ATTACHMENTS

- A. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, presized a minimum of 8 oz./sq. yd..
 - 1. Tape Width: 4 inches.
- B. Bands: 3/4 inch wide, in one of the following non-ferrous materials compatible with jacket:
 - 1. Stainless Steel: ASTM A 666, Type 304; 0.020 inch thick.
 - 2. Aluminum: 0.007 inch thick.
 - 3. Brass: 0.010 inch thick.
 - 4. Nickel-Copper Alloy: 0.005 inch thick.
- C. Wire: 0.080-inch, nickel-copper alloy; 0.062-inch, soft-annealed, stainless steel.

2.5 VAPOR RETARDERS

- A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry pipe and fitting surfaces. Remove materials that will adversely affect insulation application.

3.3 GENERAL APPLICATION REQUIREMENTS

- A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.
- B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each piping system.

- C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Apply insulation with longitudinal seams at top and bottom of horizontal pipe runs.
- E. Apply 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. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.
- H. Keep insulation materials dry during application and finishing.
- I. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.
- J. Apply insulation with the least number of joints practical.
- K. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated. Refer to special instructions for applying insulation over fittings, valves, and specialties.
- L. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic.
 - 1. Apply insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor retarders are indicated, extend insulation on anchor legs at least 12 inches from point of attachment to pipe and taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
 - 3. Install insert materials and apply insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.
- M. Insulation Terminations: For insulation application where vapor retarders are indicated, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
- N. Apply adhesives and mastics at the manufacturer's recommended coverage rate.
- O. Apply insulation with integral jackets as follows:
 - 1. Pull jacket tight and smooth.
 - 2. Circumferential Joints: Cover with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive.

3. Longitudinal Seams: Overlap jacket seams at least 1-1/2 inches. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap.
 - a. Exception: Do not staple longitudinal laps on insulation having a vapor retarder.
 4. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.
 5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor-retarder mastic.
- P. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.
- Q. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions.
 1. Firestopping and fire-resistive joint sealers are specified in Division 7 Section "Firestopping."
- R. Floor Penetrations: Apply insulation continuously through floor assembly.
 1. For insulation with vapor retarders, seal insulation with vapor-retarder mastic where floor supports penetrate vapor retarder.

3.4 MINERAL-FIBER INSULATION APPLICATION

- A. Apply insulation to straight pipes and tubes as follows:
 1. Secure each layer of preformed pipe insulation to pipe with non-ferrous wire, tape, or bands without deforming insulation materials.
 2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic. Apply vapor retarder to ends of insulation at intervals of 15 to 20 feet to form a vapor retarder between pipe insulation segments.
 3. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.
- B. Apply insulation to flanges as follows:
 1. Apply preformed pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
 4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch, and seal joints with vapor-retarder mastic.
- C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
 2. When premolded insulation elbows and fittings are not available, apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire, tape, or bands.
 3. Cover fittings with heavy PVC fitting covers. Overlap PVC covers on pipe insulation jackets at least 1 inch at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
- D. Apply insulation to valves and specialties as follows:
1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
 2. When premolded insulation sections are not available, apply glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to stainer basket without disturbing insulation.
 3. Apply insulation to flanges as specified for flange insulation application.
 4. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
 5. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.5 FIELD-APPLIED JACKET APPLICATION

- A. Apply glass-cloth jacket, where indicated, directly over bare insulation or insulation with factory-applied jackets.
1. Apply jacket smooth and tight to surface with 2-inch overlap at seams and joints.
 2. Embed glass cloth between two 0.062-inch- thick coats of jacket manufacturer's recommended adhesive.
 3. Completely encapsulate insulation with jacket, leaving no exposed raw insulation.
- B. Foil and Paper Jackets: Apply foil and paper jackets where indicated.
1. Draw jacket material smooth and tight.
 2. Apply lap or joint strips with the same material as jacket.
 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 4. Apply jackets with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.

5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-retarder mastic.
- C. Apply PVC jacket where indicated, with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

3.6 FINISHES

- A. Glass-Cloth Jacketed Insulation: Paint insulation finished with glass-cloth jacket as specified in Division 9 Section "Painting."
- B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

3.7 PIPING SYSTEM APPLICATIONS

- A. Insulation materials and thicknesses are specified in schedules at the end of this Section.
- B. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:
 1. Flexible connectors.
 2. Vibration-control devices.
 3. Fire-suppression piping.
 4. Drainage piping located in crawl spaces, unless otherwise indicated.
 5. Below-grade piping, unless otherwise indicated.
 6. Chrome-plated pipes and fittings, unless potential for personnel injury.
 7. Air chambers, unions, strainers, check valves, plug valves, and flow regulators.

3.8 FIELD QUALITY CONTROL

- A. Inspection: Perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:
 1. Inspect fittings and valves randomly selected by Engineer.
- B. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.
- C. Reinstall insulation and covers on fittings and valves uncovered for inspection according to these Specifications.

3.9 INSULATION APPLICATION SCHEDULE, GENERAL

- A. Refer to insulation application schedules for required insulation materials, vapor retarders, and field-applied jackets.
- B. Application schedules identify piping system and indicate pipe size ranges and material, thickness, and jacket requirements.

3.10 INTERIOR INSULATION APPLICATION SCHEDULE

A. Table 3.13a

Service	Operating / Ambient Temp (°F)	Material	Thickness (in)	Layers	Vapor Retarder Required	Field Applied Jacket
Domestic and Laboratory hot and recirculated hot water: Copper Pipe, 1¼" and smaller	60 to 140	Mineral fiber	½	1	No	None
Domestic and Laboratory hot and recirculated hot water: Copper Pipe, 1½" to 2"	60 to 140	Mineral fiber	1	1	No	None
Domestic and Laboratory cold water: Copper Pipe, 1¼" and smaller	35 to 60	Mineral fiber	½	1	Yes	None
Domestic and Laboratory cold water: Copper Pipe, 1½" to 2"	35 to 60	Mineral fiber	1	1	Yes	None
Exposed sanitary drains and domestic water supplies and stops for fixtures for the disabled	35 to 120	Mineral fiber	½	1	No	PVC P-trap and supply covers
Rainwater conductors: Cast Iron Pipe, 1¼" and smaller: ½"	32 to 100	Mineral fiber	½	1	Yes	None
Rainwater conductors: Cast Iron Pipe, 1½" to 2"	32 to 100	Mineral fiber	1	1	Yes	None
Rainwater conductors: Cast Iron Pipe, 2½" and larger	32 to 100	Mineral fiber	1	1	Yes	None
Roof drain bodies	32 to 100	Mineral fiber	1	1	Yes	None
Condensate drain piping	35 to 75	Mineral fiber	1	1	Yes	None

END OF SECTION

SECTION 22 11 16

DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes domestic potable and non-potable water piping from locations indicated to fixtures and equipment inside the building.
- B. Related Sections include the following:
 - 1. Division 22 0519 Section "Plumbing Meters and Gages" for thermometers, pressure gages, and fittings.
 - 2. Division 22 3000 Section "Plumbing Equipment" for water distribution piping specialties.

1.3 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing domestic water piping systems with the following minimum working-pressure ratings, unless otherwise indicated:
 - 1. Domestic Water Distribution Piping: 125 psig.

1.4 SUBMITTALS

- A. Product Data: For pipe, tube, fittings, and couplings.
- B. Water Samples: Specified in "Cleaning" Article in Part 3.
- C. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 61, "Drinking Water System Components-Health Effects; Sections 1 through 9," for potable domestic water piping and components.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

- B. Transition Couplings for Aboveground Pressure Piping: Coupling or other manufactured fitting the same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.2 COPPER TUBING

- A. Hard Copper Tube: ASTM B 88, Types K and L, water tube, drawn temper.
 - 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought- copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end. Furnish Class 300 flanges if required to match piping.
 - 3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint.

2.3 VALVES

- A. Refer to Division 22 Section "Plumbing Valves" for bronze and cast-iron, general-duty valves.
- B. Refer to Division 22 Section "Plumbing Equipment" for balancing and drain valves.

PART 3 - EXECUTION

3.1 EXCAVATION

- A. Refer to Division 31 Section "Earthwork" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

- 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 may be used on aboveground piping, unless otherwise indicated.
- C. Aboveground Domestic Water Piping: Use any of the following piping materials for each size range:
 - 1. NPS 3 and Smaller: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
- D. Non-potable-Water Piping: Use any of the following piping materials for each size range:
 - 1. NPS 4 and Smaller: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
- E. Re-circulating Domestic and Laboratory Hot Water Piping: Use any of the following piping materials for each size range:
 - 1. NPS 3 and Smaller: Hard copper tube, Type K; copper pressure fittings; and soldered joints.

3.3 VALVE APPLICATIONS

- A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
 - 1. Shutoff Duty: Use bronze ball valves for piping NPS 4 and smaller.
 - 2. Throttling Duty: Use bronze ball valves for piping NPS 4 and smaller.
 - 3. Hot-Water-Piping, Balancing Duty: Use bronze ball valves for piping NPS 4 and smaller with memory stop.
 - 4. Drain Duty: Hose-end drain valves.

3.4 PIPING INSTALLATION

- A. Refer to Division 22 Section "Plumbing Materials and Methods" for basic piping installation.
- B. Extend domestic water service piping to exterior water distribution piping in sizes and locations indicated.
- C. Install aboveground domestic water piping level with 0.25 percent slope downward toward drain and plumb.
- D. Fill water piping. Check components to determine that they are not air bound and that piping is full of water.
- E. Perform the following steps 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. Remove plugs used during testing of piping and plugs used for temporary sealing of piping during installation.
 - 5. Remove and clean strainer screens. Close drain valves and replace drain plugs.
- F. Check plumbing equipment and specialties and verify proper settings, adjustments, and operation.

3.5 JOINT CONSTRUCTION

- A. Refer to Division 22 Section "Plumbing Materials and Methods" for basic piping joint construction.
- B. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.6 VALVE INSTALLATION

- A. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment. Use ball valves.

- B. Install shutoff valve on each water supply to equipment and on each water supply to plumbing fixtures without supply stops. Use ball valves.
- C. Install drain valves for equipment, at base of each water riser, at low points in horizontal piping, and where required to drain water piping.
 - 1. Install hose-end drain valves at low points in water mains, risers, and branches.
- D. Install balancing valve in each hot-water circulation return branch and discharge side of each pump and circulator. Set balancing valves partly open to restrict but not stop flow. Use ball valves. Refer to Division 22 Section "Plumbing Equipment" for balancing valves.

3.7 HANGER AND SUPPORT INSTALLATION

- A. Refer to Division 22 Section "Plumbing Hangers and Supports" for pipe hanger and support devices. Install the following:
 - 1. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs: According to the following:
 - a. 100 Feet and Less: MSS Type 1, adjustable, clevis hangers.
 - 3. Base of Vertical Piping: MSS Type 52, spring hangers.
 - 4. Non-metallic supports: Provide where indicated on plans.
- B. Install supports according to Division 22 Section "Plumbing Hangers and Supports."
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced 1 size for double-rod hangers, to a minimum of 3/8 inch.
- E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
 - 2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
 - 3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
- F. Install supports for vertical copper tubing every 10 feet.
- G. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.
- H. Hangers for insulated piping shall be large enough to encompass the insulation and the metal saddle.

3.8 CONNECTIONS

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

- C. Connect domestic water piping to service piping with shutoff valve, and extend and connect to the following:
 - 1. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section "Plumbing Fixtures."
 - 2. 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.

3.9 FIELD QUALITY CONTROL

- A. Inspect domestic water piping as follows:
 - 1. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction and the university representative.
 - 2. During installation, notify authorities having jurisdiction and the university representative at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction and the university representative:
 - a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - b. Final Inspection: Arrange for final inspection by authorities having jurisdiction and the university representative to observe tests specified below and to ensure compliance with requirements.
 - 3. Reinspection: If authorities having jurisdiction or the university representative find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
 - 4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction and the university representative.
- B. Test domestic water piping 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 domestic water piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 3. Cap and subject piping to static water pressure of a minimum of 100 psig or 1-1/2 times the maximum working pressure, whichever is greater 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.
 - 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.

3.10 ADJUSTING

- A. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
 - 1. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.

3.11 CLEANING

- A. Clean and disinfect potable and nonpotable domestic water piping as follows:
 - 1. Flush all new water main systems until no dirty water appears at the point of water discharge. The new water main system shall then be disinfected. Disinfect with a water and chlorine solution of at least 50 parts per million (ppm) with contact to all parts of the system for at least 24 hours. The University Environmental Hygiene Officer shall approve any alternative disinfecting methods. An approved sampling line and/or tap shall be provided.
 - 2. New potable water distribution systems shall be flushed until the water runs clear and then disinfected. Disinfect all parts of the buildings potable water system in accordance with procedures specified in the Department of Health, Minnesota Plumbing Code, Chapter 4715.
 - 3. The DEHS Environmental Hygiene Officer shall be notified at least 48 hours prior to disinfecting any potable water system.
 - 4. After disinfecting, flush the entire water system to reduce the chlorine concentration to 0.0 ppm or normal municipal levels.
 - 5. Satisfactory bacteriological testing results of the water in accordance with the EPA Safe Drinking Water Act must be completed before placing the water service and/or system in service for consumption as potable water.
 - 6. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
- B. Prepare and submit reports of purging and disinfecting activities.
- C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

END OF SECTION 22 1116

SECTION 22 1316

SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes soil and waste, sanitary drainage and vent piping inside the building and to locations indicated.
- B. Related Sections include the following:
 - 1. Division 22 Section "Plumbing Specialties" for soil, waste, and vent piping systems specialties.

1.3 DEFINITIONS

- A. The following are industry abbreviations for plastic and rubber piping materials:
 - 1. EPDM: Ethylene-propylene-diene terpolymer.
 - 2. NBR: Acrylonitrile-butadiene rubber.
 - 3. PE: Polyethylene plastic.
 - 4. PVC: Polyvinyl chloride plastic.

1.4 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing piping systems with the following minimum working-pressure ratings, unless otherwise indicated:
 - 1. Soil, Waste, and Vent Piping: 10-foot head of water.

1.5 SUBMITTALS

- A. Product Data: For pipe, tube, fittings, and couplings.

1.6 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping; "NSF-drain" for plastic drain piping; "NSF-tubular" for plastic continuous waste piping; and "NSF-sewer" for plastic sewer piping.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.
- B. Flexible Transition Couplings for Underground Nonpressure Piping: ASTM C 1173 with elastomeric sleeve. Include ends of same sizes as piping to be joined and include corrosion-resistant metal band on each end.

2.2 CAST-IRON SOIL PIPING

- A. Hub-and-Spigot Pipe and Fittings: ASTM A 74, Service class.
 - 1. Gaskets: ASTM C 564, rubber.
- B. Hubless Pipe and Fittings: ASTM A 888 or CISPI 301.
 - 1. Couplings: ASTM C 1277 assembly of metal housing, corrosion-resistant fasteners, and ASTM C 564 rubber sleeve with integral, center pipe stop.
 - a. Heavy-Duty, Type 304, Stainless-Steel Couplings: ASTM A 666, Type 304, stainless-steel shield; stainless-steel bands; and sleeve.
 - (1) NPS 1-1/2 to NPS 4: 3-inch- wide shield with 4 bands.
 - b. Heavy-Duty, Cast-Iron Couplings: ASTM A 48, 2-piece, cast-iron housing; stainless-steel bolts and nuts; and sleeve.
 - 2. Sovent Fittings: ASME B16.45 or ASSE 1043, hubless, aerator and deaerator.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Transition and special fittings with pressure ratings at least equal to piping pressure ratings may be used in applications below, unless otherwise indicated.
- B. Flanges may be used on aboveground pressure piping, unless otherwise indicated.
- C. Aboveground, Soil, Waste, and Vent Piping: Use any of the following piping materials for each size range:
 - 1. NPS 1-1/2 to NPS 6: Hubless, cast-iron soil piping and heavy-duty, Type 301, stainless steel couplings.
 - 2. NPS 2 to NPS 4: Service class, cast-iron soil piping; gaskets; and gasketed joints.
 - 3. NPS 2 to NPS 4: Hubless, cast-iron soil piping and one of the following:

3.2 PIPING INSTALLATION

- A. Refer to Division 33 Section "Sanitary Sewerage" for Project-site sanitary sewer piping.

- B. Refer to Division 22 Section "Plumbing Materials and Methods" for basic piping installation.
- C. Install cleanouts at grade where building sanitary drains connect to building sanitary sewers.
- D. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Refer to Division 22 Section "Plumbing Materials and Methods" for wall penetration systems.
- E. 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."
- F. 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 2 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.
- G. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:
 - 1. Building Sanitary Drain and Horizontal Sanitary Drainage Piping: 1/4"/lf downward in direction of flow for piping NPS 2-1/2" and smaller; 1/8"/lf downward in direction of flow for piping NPS 3" 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.
- H. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
- I. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction and the university representative.

3.3 JOINT CONSTRUCTION

- A. Refer to Division 22 Section "Plumbing Materials and Methods" for basic piping joint construction.
- B. Cast-Iron, Soil-Piping Joints: Make joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
 - 1. Gasketed Joints: Make with rubber gasket matching class of pipe and fittings.
 - 2. Hubless Joints: Make with rubber gasket and sleeve or clamp.

3.4 HANGER AND SUPPORT INSTALLATION

- A. Refer to Division 22 Section "Plumbing Hangers and Supports" for pipe hanger and support devices. Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
 2. Individual, Straight, Horizontal Piping Runs: According to the following:
 - a. 100 Feet and Less: MSS Type 1, adjustable, clevis hangers.
 3. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Install supports according to Division 22 Section "Hangers and Supports."
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.
- E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
 2. NPS 2-1/2 to 3-1/2: 60 inches with 1/2-inch rod.
 3. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- F. Install supports for vertical cast-iron soil piping every story height.
- G. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/2 and NPS 2: 32 inches with 3/8-inch rod.
 2. NPS 2-1/2 to 3-1/2: 32 inches with 1/2-inch rod.
- H. Install supports for vertical PVC piping every 48" for sizes NPS 1-1/2 and smaller, at every story height NPS 2 and larger for sizes.
1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section "Plumbing Fixtures."
 2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
 3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section "Plumbing Specialties."
 4. 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.
- I. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.5 CONNECTIONS

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

- B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect drainage and vent piping to the following:
 - 1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 4000 Section "Plumbing Fixtures."
 - 2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
 - 3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 3000 Section "Plumbing Equipment."
 - 4. 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.

3.6 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction and the university representative at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction and the university representative.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction or the university representative find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction and the university representative.
- 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.

3.7 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.

END OF SECTION 22 1316

SECTION 22 14 13

STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Pipe, tube, and fittings.
 - 2. Specialty pipe fittings.

1.3 PERFORMANCE REQUIREMENTS

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

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control reports.

1.5 QUALITY ASSURANCE

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

1.6 PROJECT CONDITIONS

- A. Interruption of Existing Storm-Drainage 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 storm-drainage service.
 - 2. Do not proceed with interruption of storm-drainage service Owner's written permission.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 GALVANIZED-STEEL PIPE AND FITTINGS (ABOVE GROUND ONLY)

- A. Galvanized-Steel Pipe: ASTM A 53, Type E, Standard Weight. Include square-cut-grooved or threaded ends matching joining method.
- B. Galvanized Cast-Iron Drainage Fittings: ASME B16.12 threaded.
- C. Steel-Pipe Pressure Fittings:
 - 1. Galvanized-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53 or ASTM A 106, Schedule 40, seamless steel pipe. Include ends matching joining method.
 - 2. Malleable-Iron Unions: ASME B16.39; Class 300; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
 - 3. Galvanized Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, standard pattern.
- D. Cast-Iron Flanges: ASME B16.1, Class 125.
 - 1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 - 2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

2.3 COPPER TUBE AND FITTINGS (ABOVE GROUND ONLY)

- A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
- B. Copper Drainage Fittings: ASME B16.23, cast-copper fittings or ASME B16.29, wrought-copper, solder-joint fittings.
- C. Hard Copper Tube: ASTM B 88, Type K, Type L, Type M, water tube, drawn temper.
- D. Copper Pressure Fittings:
 - 1. Copper Fittings: ASME B16.18, cast-copper-alloy fittings or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
- E. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.

1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- F. 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, Nonpressure Transition Couplings:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - (1) Dallas Specialty & Mfg. Co.
 - (2) Fernco Inc.
 - (3) 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, Nonpressure Transition Couplings:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - (1) Cascade Waterworks Mfg. Co.
 - (2) Mission Rubber Company; 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] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, 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, 250 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 minimum.
 - (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) 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. 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.
- b. Description:
- (1) Electroplated steel nipple complying with ASTM F 1545.
 - (2) Pressure Rating: 300 psig at 225 deg .
 - (3) End Connections: Male threaded.
 - (4) Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. Aboveground storm drainage piping NPS 6 and smaller shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 2. Hubless, cast-iron soil pipe and fittings; CISPI, heavy-duty, hubless-piping couplings; and coupled joints.
- C. Aboveground storm drainage piping NPS 8 to NPS 12 shall be any of the following:
1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 2. Hubless, cast-iron soil pipe and fittings; [CISPI,] [heavy-duty,] hubless-piping couplings; and coupled joints.
- D. Aboveground storm drainage force mains NPS 1-1/2 and NPS 2 shall be any of the following:
1. Type K or L hard copper tube, copper pressure fittings, and soldered joints.
 2. Standard weight galvanized-steel pipe, pressure fittings, and threaded joints.
- E. Aboveground storm drainage force mains **NPS 2-1/2 to NPS 6** shall be **any of** the following:
1. Type K or L hard copper tube, copper pressure fittings, and soldered joints.
 2. Standard weight galvanized-steel pipe, cast iron 125# pressure fittings, and threaded joints.
 3. Fitting-type transition couplings if dissimilar pipe materials.

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations from layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use

proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

- K. Install storm drainage piping at the following minimum slopes unless otherwise indicated:
 - 1. Building Storm Drain and Horizontal Storm Drainage Piping: Minimum of 1/8"/LF downward in direction of flow for piping.
- L. Install steel piping according to applicable plumbing code.
- M. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."
- N. Install force mains at elevations indicated.
- O. Plumbing Specialties:
 - 1. Install backwater valves in storm drainage gravity-flow piping. Comply with requirements for backwater valves specified in Division 22 Section "Plumbing Specialties."
 - 2. Install cleanouts at grade where building storm drains connect to building storm sewers in storm drainage piping. Comply with requirements for cleanouts specified in Division 22 Section "Plumbing Specialties."
 - 3. Install drains in storm drainage gravity-flow piping. Comply with requirements for drains specified in Division 22 Section "Plumbing Specialties."
- P. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Plumbing Sleeves and Sleeve Seals."
- R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Plumbing Sleeves and Sleeve Seals."

3.3 JOINT CONSTRUCTION

- A. 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.
- B. Join copper tube and fittings with soldered joints according to ASTM B 828 procedure. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.

- C. 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: Unshielded, nonpressure transition couplings.
 - 3. In Aboveground Force-Main Piping: Fitting-type transition couplings.
- B. Dielectric Fittings:
 - 1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
 - 2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples or unions.
 - 3. Dielectric Fittings for **NPS 2-1/2 to NPS 4**: Use dielectric flanges, flange kits or nipples.
 - 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 "Plumbing General-Duty Valves."
- B. Shutoff Valves: Install shutoff valve on each sump pump discharge.
 - 1. Install gate or full-port ball valve for piping NPS 2 and smaller.
 - 2. 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 pipe hanger and support devices and installation specified in Division 22 Section "Plumbing Hangers and Supports."
 - 1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
 - 2. Install stainless-steel or fiberglass pipe hangers for horizontal piping in corrosive environments.
 - 3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
 - 4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
 - 5. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 6. Individual, Straight, Horizontal Piping Runs:

- a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
7. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
- B. Support horizontal piping and tubing within 12 inches of each fitting, valve, or couplings.
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.
- E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
 2. NPS 3: 60 inches with 1/2-inch rod.
 3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
 4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
 5. Spacing for 10-foot pipe lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- F. Install supports for vertical cast-iron soil piping every 15 feet or each floor.
- G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/4: 84 inches with 3/8-inch rod.
 2. NPS 1-1/2: 108 inches with 3/8-inch rod.
 3. NPS 2: 10 feet with 3/8-inch rod.
 4. NPS 2-1/2: 11 feet with 1/2-inch rod.
 5. NPS 3: 12 feet with 1/2-inch rod.
 6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
 7. NPS 6 and NPS 8: 12 feet with 3/4-inch rod.
- H. Install supports for vertical steel piping every 15 feet of each floor.
- I. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/4: 72 inches with 3/8-inch rod.
 2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
 3. NPS 2-1/2: 108 inches with 1/2-inch rod.
 4. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.

- 5. NPS 4 and NPS 5: 10 feet with 5/8-inch rod.
- 6. NPS 6: 10 feet with 3/4-inch rod.
- J. Install supports for vertical copper tubing every 10 feet on each floor.
- K. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect 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 "Plumbing Identification."

3.9 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Test Procedure: Test storm drainage piping, 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 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.

3.10 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.

END OF SECTION 221413

SECTION 22 3000

PLUMBING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following plumbing specialties:
 - 1. Backflow preventers.
 - 2. Balancing valves.
 - 3. Strainers.
 - 4. Key-operation hydrants.
 - 5. Drain valves.
 - 6. Miscellaneous piping specialties.
 - 7. Sleeve penetration systems.
 - 8. Flashing materials.
 - 9. Cleanouts.
 - 10. Floor drains.
- B. Related Sections include the following:
 - 1. Division 22 0519 Section "Plumbing Meters and Gages" for water meters, thermometers, and pressure gages.

1.3 DEFINITIONS

- A. The following are industry abbreviations for plastic piping materials:
 - 1. ABS: Acrylonitrile-butadiene-styrene plastic.
 - 2. PE: Polyethylene plastic.
 - 3. PUR: Polyurethane plastic.
 - 4. PVC: Polyvinyl chloride plastic.

1.4 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing piping systems with following minimum working-pressure ratings, unless otherwise indicated:
 - 1. Domestic Water Piping: 125 psig.

2. Sanitary Waste and Vent Piping: 10-foot head of water.
3. Storm Drainage Piping: 10-foot head of water.

1.5 SUBMITTALS

- A. Product Data: Include rated capacities and shipping, installed, and operating weights. Indicate materials, finishes, dimensions, required clearances, and methods of assembly of components; and piping and wiring connections for the following:
 1. Backflow preventers.
 2. Strainers.
 3. Drain valves.
 4. Cleanouts, floor drains, and roof drains.
 5. Vent caps, vent terminals, and roof flashing assemblies.
 6. Sleeve penetration systems.
- B. Field test reports.
- C. Maintenance Data: For plumbing specialties to include in maintenance manuals. Include the following:
 1. Backflow preventers.

1.6 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of plumbing specialties and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."
- B. Plumbing specialties 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. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for piping materials and installation.
- E. NSF Compliance:
 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components. Include marking "NSF-pw" on plastic potable-water piping and "NSF-dwv" on plastic drain, waste, and vent piping.
 2. Comply with NSF 61, "Drinking Water System Components--Health Effects, Sections 1 through 9," for potable domestic water plumbing specialties.

1.7 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. Operating Key Handles: Equal to 100 percent of amount installed for each key-operated hose bib and hydrant installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 BACKFLOW PREVENTERS

- A. Manufacturers:
 - 1. Ames Co., Inc.
 - 2. Cla-Val Co.
 - 3. Conbraco Industries, Inc.
 - 4. Mueller Co.; Hersey Meters Div.
 - 5. Sparco, Inc.
 - 6. Watts Industries, Inc.; Water Products Div.
 - 7. Zurn Industries, Inc.; Wilkins Div.
- B. General: ASSE standard, backflow preventers.
 - 1. NPS 2 and Smaller: Bronze body with threaded ends.
 - 2. NPS 2-1/2 and Larger: Bronze, cast-iron, steel, or stainless-steel body with flanged ends.
 - a. Interior Lining: AWWA C550 or FDA-approved, epoxy coating for backflow preventers having cast-iron or steel body.
 - 3. Interior Components: Corrosion-resistant materials.
 - 4. Exterior Finish: Polished chrome plate if used in chrome-plated piping system.
 - 5. Strainer: On inlet, if indicated.
- C. Hose-Connection Vacuum Breakers: ASSE 1011, nickel plated, with non-removable and manual drain features, and ASME B1.20.7, garden-hose threads on outlet. Units attached to rough-bronze-finish hose connections may be rough bronze.
- D. Reduced-Pressure-Principle Backflow Preventers: ASSE 1013, suitable for continuous pressure application. Include outside screw and yoke gate valves on inlet and outlet, and

strainer on inlet; test cocks; and pressure-differential relief valve with ASME A112.1.2 air-gap fitting located between two positive-seating check valves.

1. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
- E. Single – Detector Check Valve Assembly Backflow Preventers: ASSE 1048, FM approved or UL listed, and suitable for continuous pressure application. Include outside screw and yoke gate valves on inlet and outlet. Include test cocks; positive-seating, spring loaded, epoxy-coated check valve; and bypass with displacement-type water meter, valves, and single-check backflow preventer.
1. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.

2.3 STRAINERS

- A. Strainers: Y-pattern, unless otherwise indicated, and full size of connecting piping. Include ASTM A 666, Type 304, stainless-steel screens with 3/64-inch round perforations, unless otherwise indicated.
1. Pressure Rating: 125-psig minimum steam working pressure, unless otherwise indicated.
 2. NPS 2 and Smaller: Bronze body, with female threaded ends.
 3. NPS 2-1/2 and Larger: Cast-iron body, with interior AWWA C550 or FDA-approved, epoxy coating and flanged ends.
 4. Y-Pattern Strainers: Screwed screen retainer with centered blowdown.
 - a. Drain: Factory- or field-installed, hose-end drain valve.

2.4 DRAIN VALVES

- A. Hose-End Drain Valves: MSS SP-110, NPS 3/4 ball valve, rated for 400-psig minimum CWP. Include two-piece, copper-alloy body with standard port, chrome-plated brass ball, replaceable seats and seals, blowout-proof stem, and vinyl-covered steel handle.
1. Inlet: Threaded or solder joint.
 2. Outlet: Short-threaded nipple with ASME B1.20.7, garden-hose threads and cap.
- B. Hose-End Drain Valve: MSS SP-80, gate valve, Class 125, ASTM B 62 bronze body, with NPS 3/4 threaded or solder-joint inlet and ASME B1.20.7, garden-hose threads on outlet and cap. Hose bibs are prohibited for this application.

2.5 MISCELLANEOUS PIPING SPECIALTIES

- A. Air Vents: Float type for automatic air venting.
1. Bolted Construction: Bronze body with replaceable, corrosion-resistant metal float and stainless-steel mechanism and seat; threaded NPS 1/2 minimum inlet; 125-psig minimum pressure rating at 140 deg F; and threaded vent outlet.
 2. Welded Construction: Stainless-steel body with corrosion-resistant metal float, stainless-steel mechanism and seat, threaded NPS 3/8 minimum inlet, 150-psig minimum pressure rating, and threaded vent outlet.

- B. Roof Flashing Assemblies: Manufactured assembly made of 6-lb/sq. ft., 0.0938-inch-thick, lead flashing collar and skirt extending at least 10 inches from pipe with galvanized steel boot reinforcement, and counterflashing fitting.
 - 1. Manufacturers:
 - a. Acorn Engineering Company; Elmdor/Stoneman Div.
 - 2. Open-Top Vent Cap: Without cap.
 - 3. Low-Silhouette Vent Cap: With vandal-proof vent cap.
 - 4. Extended Vent Cap: With field-installed, vandal-proof vent cap.
- C. Open Drains: 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.
- D. Deep-Seal Traps: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap seal primer valve connection.
 - 1. NPS 2: 4-inch- minimum water seal.
 - 2. NPS 2-1/2 and Larger: 5-inch- minimum water seal.
- E. Fixed Air-Gap Fittings: Manufactured cast-iron or bronze drainage fitting with semiopen top with threads or device to secure drainage inlet piping in top and bottom spigot or threaded outlet larger than top inlet. Include design complying with ASME A112.1.2 that will provide fixed air gap between installed inlet and outlet piping.
- F. Stack Flashing Fittings: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
- G. Vent Caps: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and set-screws to secure to vent pipe.
- H. Vent Terminals: Commercially manufactured, shop- or field-fabricated, frost-proof assembly constructed of galvanized steel, copper, or lead-coated copper. Size to provide 1-inch enclosed air space between outside of pipe and inside of flashing collar extension, with counterflashing.
- I. Expansion Joints: ASME A112.21.2M, assembly with cast-iron body with bronze sleeve, packing gland, and packing; of size and end types corresponding to connected piping.
- J. Conductor Nozzles: Bronze body with threaded inlet for connected conductor size, and bronze wall flange with mounting holes.
 - 1. Finish: Polished bronze.

2.6 SLEEVE PENETRATION SYSTEMS

- A. Manufacturers:
 - 1. ProSet Systems, Inc.
- B. Description: UL 1479, through-penetration firestop assembly consisting of sleeve and stack fitting with firestopping plug.

1. 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.
2. Stack Fitting: ASTM A 48, gray-iron, hubless-pattern, wye-branch stack fitting with neoprene O-ring at base and gray-iron plug in thermal-release harness in branch. Include PVC protective cap for plug.
 - a. Special Coating: Include corrosion-resistant interior coating on fittings for plastic chemical waste and vent stacks.

2.7 FLASHING MATERIALS

- A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:
 1. General Use: 4-lb/sq. ft., 0.0625-inch thickness.
 2. Vent Pipe Flashing: 3-lb/sq. ft., 0.0469-inch thickness.
 3. Burning: 6-lb/sq. ft., 0.0938-inch thickness.
- B. Copper Sheet: ASTM B 152, of the following minimum weights and thicknesses, unless otherwise indicated:
 1. General Applications: 12 oz./sq. ft..
 2. Vent Pipe Flashing: 8 oz./sq. ft..
- C. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness, unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.
- D. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.
- E. Fasteners: Metal compatible with material and substrate being fastened.
- F. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
- G. Solder: ASTM B 32, lead-free alloy.
- H. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

2.8 CLEANOUTS

- A. Cleanouts: Comply with ASME A112.36.2M or ASME A112.3.1.
 1. Application: Floor cleanout, Wall cleanout or for installation in exposed piping.
 2. Manufacturers:
 - a. Josam Co.
 - b. Josam Co., Blucher-Josam Div.
 - c. Sioux Chief Manufacturing Co., Inc.
 - d. Smith, Jay R. Mfg. Co.

- e. Tyler Pipe, Wade Div.
 - f. Watts Industries, Inc., Drainage Products Div.
 - g. Zurn Industries, Inc., Jonespec Div.
 - h. Zurn Industries, Inc., Specification Drainage Operation
3. Body or Ferrule Material: Cast iron.
 4. Closure: Brass plug with straight threads and gasket.
 5. Adjustable Housing Material: Cast iron with threads.
 6. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
 7. Frame and Cover Shape: Round, Minneapolis pattern type brass.

2.9 FLOOR DRAINS

- A. Floor Drains: Comply with ASME A112.21.1M, ASME A112.21.1M with ASME A112.14.1, backwater valve or ASME A112.3.1.
 1. Application: Area drain, Floor drain or Funnel floor drain.
 2. Manufacturers:
 - a. Josam Co.
 - b. Josam Co., Blucher-Josam Div.
 - c. Sioux Chief Manufacturing Co., Inc.
 - d. Smith, Jay R. Mfg. Co.
 - e. Tyler Pipe, Wade Div.
 - f. Watts Industries, Inc., Drainage Products Div.
 - g. Zurn Industries, Inc., Jonespec Div.
 - h. Zurn Industries, Inc., Specification Drainage Operation
 3. Body Material: Gray iron.
 4. Seepage Flange: Required.
 5. Clamping Device: Required.
 6. Top or Strainer Material: Nickel bronze.
 7. Top of Body and Strainer Finish: Nickel bronze.
 8. Top Shape: Round.
 9. Trap Material: Cast iron.
 10. Chloraloy membrane flashing shall extend 18 inches from the clamping ring on all floor drains located in slabs not on grade.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Division 22 Section "Plumbing Materials and Methods" for piping joining materials, joint construction, and basic installation requirements.
- B. 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 not acceptable for this application.
 - 3. Do not install bypass piping around backflow preventers.
- C. Install strainers on supply side of each control valve and solenoid valve.
- D. 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.
- E. Install cleanout deck plates with top flush with finished floor, for floor cleanouts for piping below floors.
- F. Install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall, for cleanouts located in concealed piping.
- G. Install flashing flange and clamping device with each stack and cleanout passing through floors with waterproof membrane.
- H. Install vent flashing sleeves on stacks passing through roof. Secure over stack flashing according to manufacturer's written instructions.
- I. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.
- J. 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.
- K. Fasten wall-hanging plumbing specialties securely to supports attached to building substrate if supports are specified and to building wall construction if no support is indicated.
- L. Fasten recessed-type plumbing specialties to reinforcement built into walls.
- M. Install wood-blocking reinforcement for wall-mounting and recessed-type plumbing specialties.
- N. Install individual shutoff valve in each water supply to plumbing specialties. Use ball valve if specific valve is not indicated. Install shutoff valves in accessible locations. Refer to Division 22 Section "Plumbing Valves" for general-duty ball, butterfly, check, gate, and globe valves.
- O. Install air vents at piping high points. Include ball valve in inlet with hose threads for draining.
- P. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.
- Q. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Connect plumbing specialties to piping specified in other Division 22 Sections.
- D. Connect plumbing specialties and devices that require power according to Division 26 Sections.

3.3 FLASHING INSTALLATION

- A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
 - 1. Lead Sheets: Burn joints of lead sheets 6-lb/sq. ft., 0.0938-inch thickness or thicker.
 - 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 pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
 - 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
 - 3. Embedded 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. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 7 Section "Sheet Metal Flashing and Trim."
- F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.
- G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each backflow preventer, thermostatic water mixing valve, water tempering valve, trap seal primer system, grease interceptor, and oil interceptor.
 - 1. Text: 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.
 - 2. Refer to Division 22 0553 Section "Plumbing Identification" for nameplates and signs.

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled trap seal primer systems and their installation, including piping and electrical connections. Report results in writing.
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 PROTECTION

1. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
2. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 3000

SECTION 22 4000

PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes plumbing fixtures and related components.
- B. Related Sections include the following:
 - 1. Division 22 3000 Section "Plumbing Specialties" for backflow preventers and specialty fixtures not in this Section.

1.3 DEFINITIONS

- A. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.
- B. Fitting: Device that controls flow of water into or out of plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

1.4 SUBMITTALS

- A. Product Data: Include selected fixture and trim, fittings, accessories, appliances, appurtenances, furnished specialties, equipment, and supports and indicate materials and finishes, dimensions, construction details, and flow-control rates for each type of fixture indicated.
- B. Shop Drawings: Diagram power, signal and control wiring, and differentiate between manufacturer-installed and field-installed wiring.
- C. Product Certificates: Submit certificates of performance testing specified in "Source Quality Control" article.
- D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.5 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. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; about plumbing fixtures for people with disabilities.
- C. Regulatory Requirements: Comply with requirements in U.S. Architectural & Transportation Barriers Compliance Board's "Uniform Federal Accessibility Standards (UFAS), 1985-494-187" about 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. Hand Sinks: NSF 2 construction.
 2. Stainless-Steel Fixtures Other Than Service Sinks: ASME A112.19.3M.
 3. Vitreous-China Fixtures: ASME A112.19.2M.
- 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. Faucet Hose: ASTM D 3901.
 5. Faucets: ASME A112.18.1M.
 6. Hose-Connection Vacuum Breakers: ASSE 1011.
 7. Hose-Coupling Threads: ASME B1.20.7.
 8. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
 9. NSF Materials: NSF 61.
 10. Pipe Threads: ASME B1.20.1.
 11. Supply and Drain Fittings: ASME A112.18.1M.

- 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 A112.18.1M.
 - 3. Manual-Operation Flushometers: ASSE 1037.
 - 4. Tubular Brass Drainage Fittings and Piping: ASME A112.18.1M.
- J. Comply with the following applicable standards and other requirements specified for miscellaneous components:
 - 1. Floor Drains: ASME A112.21.1M.
 - 2. Hose-Coupling Threads: ASME B1.20.7.
 - 3. Off-Floor Fixture Supports: ASME A112.6.1M.
 - 4. Pipe Threads: ASME B1.20.1.
 - 5. Plastic Toilet Seats: ANSI Z124.5.
 - 6. Supply and Drain Protective Shielding Guards: ICC A117.1.
- K. 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.
- L. ARI Standard: Comply with ARI 1010, "Self Contained, Mechanically Refrigerated Drinking Water Coolers", for water coolers and with ARI's "Directory of Certified Drinking Water Coolers" for type and style classifications.

1.6 COORDINATION

- A. Coordinate roughing-in and final plumbing fixture locations, and verify that fixtures can be installed to comply with original design and referenced standards.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. For fixture descriptions in other Part 2 articles where the subparagraph titles "Manufacturers" introduce a list of manufacturers and their products or manufacturers only, the following requirements apply for product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified in other Part 2 articles.

2.2 LAVATORY FAUCETS

- A. Lavatory Faucet: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes and outlet with spout and fixture receptor.
 - 1. Manufacturers:

- a. Chicago Faucet Co. Model No. 802A with aerator, 802A-317, 895-317 or university approved equal

2.3 SINK FAUCETS

- A. Sink Faucet: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes and outlet with spout and fixture receptor.
 1. Manufacturers:
 - a. Chicago Faucet Co.

2.4 FLUSHOMETERS

- A. Flushometer: Cast-brass body with corrosion-resistant internal components, non-hold-open feature, control stop with check valve, vacuum breaker, and copper or brass tubing, and polished chrome-plated finish on exposed parts.
 1. Manufacturers:
 - a. Sloan Valve Co.

2.5 TOILET SEATS

- A. Toilet Seat: Solid plastic.
 1. Manufacturers:
 - a. Church Seat Co.
 - b. Olsonite Corp.

2.6 PROTECTIVE SHIELDING GUARDS

- A. Protective Shielding Guard: Manufactured, plastic covering for hot- and cold-water supplies and trap and drain piping and complying with ADA requirements.
 1. Manufacturers:
 - a. Brocar Products, Inc.
 - b. Engineered Brass Co.
 - c. McGuire Manufacturing Co., Inc.
 - d. Plumberex Specialty Products
 - e. Sanitary-Dash Manufacturing Co., Inc.
 - f. TCI Products
 - g. TRUEBRO, Inc.

2.7 FIXTURE SUPPORTS

- A. Water-Closet Support: Water-closet combination carrier designed for accessible and standard mounting height. Include single or double, vertical or horizontal, hub-and-spigot or 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.

1. Manufacturers:
 - a. Josam Co.
 - b. Smith, Jay R. Mfg. Co.
 - c. Zurn Specifications Drainage Operation
- B. Lavatory Support: Type II, lavatory carrier with concealed arms and tie rod. Include steel uprights with feet.
 1. Manufacturers:
 - a. Josam Co.
 - b. Smith, Jay R. Mfg. Co.
 - c. Zurn Specifications Drainage Operation
 2. Accessible Fixture Support: Include rectangular steel uprights.

2.8 WATER CLOSETS

- A. Water Closets: Accessible, wall- hanging, back-outlet, siphon jet, elongated bowl, vitreous-china fixture designed for flushometer valve operation.
 1. Manufacturers:
 - a. American Standard, Inc.

2.9 LAVATORIES

- A. Lavatories: Accessible, wall- hanging, vitreous-china fixture.
 1. Manufacturers:
 - a. American Standard, Inc.

2.10 SINKS

- A. Sinks: Counter-mounting, stainless-steel fixture.
 1. Manufacturers:
 - a. Dayton Products, Inc.
 - b. Elkay Manufacturing Co.
 - c. Just Manufacturing Co.

2.11 SOURCE QUALITY CONTROL

- A. Certify performance of plumbed emergency plumbing fixtures by independent testing agency acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for water soil and for waste piping systems and supports to verify actual locations and sizes of piping connections and that locations and types of supports match those indicated, before plumbing fixture installation. Use manufacturer's roughing-in data if roughing-in data are not indicated.
- B. Examine walls, floors, and cabinets for suitable conditions where fixtures are to be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FIXTURE INSTALLATION

- A. Assemble fixtures, trim, fittings, and other components according to manufacturers' written instructions.
- B. For wall-hanging fixtures, install off-floor supports affixed to building substrate.
 - 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-hanging fixtures onto waste fitting seals and attach to supports.
- D. Install wall-hanging 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 manufacturers' written instructions and 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.
- H. Install dielectric fitting in supply piping to fixture if piping and fixture connections are made of different metals. Refer to Division 22 Section "Plumbing Material and Methods" for dielectric fittings.
- I. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.
- J. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.
- K. 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.

- L. Install toilet seats on water closets.
- M. 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.
- N. Install water-supply, flow-control fittings with specified flow rates in fixture supplies at stop valves.
- O. 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.
- P. Install traps on fixture outlets.
 - 1. Exception: Omit trap on fixtures with integral traps.
 - 2. Exception: Omit trap on indirect wastes, unless otherwise indicated.
- Q. Install escutcheons at piping wall and ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Refer to Division 22 Section "Plumbing Materials and Methods" for escutcheons.
- R. Set service basins in leveling bed of cement grout. Refer to Division 22 Section "Plumbing Materials and Methods" for grout.
- S. Seal joints between fixtures and walls, floors, and counters using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Refer to Division 7 Section "Joint Sealants" for sealant and installation requirements.

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 water supplies from water distribution piping to fixtures.
- C. Connect drain piping from fixtures to drainage piping.
- D. Supply and Waste Connections to Fixtures and Equipment Specified in Other Sections: Connect fixtures and equipment with water supplies, stops, risers, traps, and waste piping specified. Use size fittings required to match fixtures and equipment. Connect to plumbing piping.
- E. Ground Equipment:
 - 1. 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 and UL 486 B.

3.4 FIELD QUALITY CONTROL

- A. Verify that installed fixtures are categories and types specified for locations where installed.
- B. Check that fixtures are complete with trim, faucets, fittings, and other specified components.

- C. Inspect installed 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. Water Cooler Testing: After electrical circuitry has been energized, test for compliance with requirements. Test and adjust controls and safeties.
- F. Report test results in writing.

3.5 ADJUSTING

- A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
- B. Adjust water pressure at faucets, and flushometer valves to produce proper flow and stream. Adjust or replace fixture flow regulators for proper flow.
- C. Replace washers and seals of leaking and dripping faucets and stops.
- D. Adjust equipment temperature settings.

3.6 CLEANING

- A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Remove paint splatters and other spots, dirt and debris. Repair damaged finish to match original finish. 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.

3.7 PROTECTION

- A. Provide protective covering for installed fixtures and fittings.
- B. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 4000

SECTION 23 0500

HVAC MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Building service outages.
 - 2. Electrical requirements for mechanical equipment.
 - 3. Welding requirements.
 - 4. Fire safety precautions
 - 5. HVAC systems commissioning
 - 6. Piping materials and installation instructions common to most piping systems.
 - 7. Dielectric fittings.
 - 8. Escutcheons.
 - 9. Grout.
 - 10. Cutting and Patching
 - 11. HVAC Demolition
 - 12. Equipment installation requirements common to equipment sections.
 - 13. Painting and finishing.
 - 14. Concrete bases.
 - 15. Supports and anchorages.

1.3 DEFINITIONS

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

- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
- E. 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.
- F. The following are industry abbreviations for rubber materials:
 - 1. EPDM: Ethylene-propylene-diene terpolymer rubber.
 - 2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

- A. Product Data: For the following:
 - 1. Dielectric fittings.
 - 2. Escutcheons.
- B. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Product Standards:
 - 1. Refer to Section 01600.
 - 2. Where products are specified by manufacturer, brand name or catalog number, this establishes the standard of quality and style of the product to be provided under the Contract, unless a change in quality or style is approved by Owner.
 - 3. All Contractor-furnished equipment, including its component parts, shall be the current standard products of the manufacturer in order to insure prompt and continuing service and replacement of parts.
 - 4. Where 2 or more units of the same class of equipment are required, these units shall be the products of a single manufacturer; however, the component parts of the equipment need not be the product of the same manufacturer.
- B. Referenced Standards:
 - 1. The following are names of technical and trade organizations, together with the corresponding acronyms, used in this Specification when citing specific standards published by these organizations:
 - a. Air-Conditioning and Refrigeration Institute (ARI)
 - b. Air Moving and Conditioning Association (AMCA)
 - c. American Boiler Manufacturers Association (ABMA)
 - d. American Concrete Institute
 - e. American Conference of Governmental Industrial Hygienists
 - f. American Gas Association (AGA)
 - g. American Institute of Steel Construction

- h. American National Standards Institute (ANSI)
 - i. American Society of Heating, Refrigeration and Air Conditioning Engineers
 - j. American Society of Mechanical Engineers (ASME)
 - k. American Society of Mechanical Engineers Unfired Pressure Vessel Code
 - l. American Society for Testing Materials (ASTM)
 - m. American Water Works Association (AWWA)
 - n. American Welding Society
 - o. ANSI Code for Power Piping B31.1
 - p. Associated Air Balance Council
 - q. Hydraulic Institute Standards for Centrifugal, Rotary and Reciprocating Pumps
 - r. Institute of Electrical and Electronic Engineers
 - s. National Association of Sheet Metal and Air Conditioning Contractors
 - t. National Board of Boiler And Pressure Vessel Inspectors
 - u. National Bureau of Standards
 - v. National Commercial and Industrial Insulation Standards
 - w. National Environmental Balancing Bureau (NEBB)
 - x. National Electrical Manufacturers Association (NEMA)
 - y. National Electric Code (NEC)
 - z. National Fire Protection Association (NFPA)
 - aa. National Safety Code for Mechanical Refrigeration
 - bb. Occupational Safety and Health Organization (OSHA)
 - cc. Tubular Exchanger Manufacturers Association (TEMA)
 - dd. Underwriters Laboratories (UL)
2. Where a reference standard is cited in this Specification, the subject to which it applies (equipment, material or work) shall be in compliance with the most recent edition of that standard.
3. None of the above, however, shall be construed as relieving Contractor from complying with any requirement in this Specification that may be in excess of, but not contrary to, the referenced standard.

1.6 BUILDING SERVICE OUTAGES

- A. Service Outage Request: The contractor shall request all building service outages through the owner's representative. The contractor shall provide a minimum notification of 24 hours.

1.7 ELECTRICAL REQUIREMENTS FOR MECHANICAL EQUIPMENT

- A. 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.

1.8 WELDING REQUIREMENTS

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- B. 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.
 - 3. Comply with the State of Minnesota Code for High Pressure Piping, Chapter 5230, for high pressure steam and condensate piping; and the Minnesota Department of Administration State Building Code, Mechanical Systems, Chapter 1345 for low pressure steam and condensate piping.
 - 4. Steam and condensate piping trades persons shall follow procedures identified in the Procedure Qualification Record and Welding Procedure Specifications identified in the 2002 University Standards and Procedures for Construction, Division 15010 Basic Mechanical Requirements.
- C. An independent testing laboratory shall radiograph selected joints, which shall be evaluated on the basis of API and ANSI construction standards appropriate for the service.

1.9 FIRE SAFETY PRECAUTIONS

- A. A Hot Works Permit is required for any temporary operation that involves open flames or produces heat and/or sparks. Such operations include, but are not limited to, brazing cutting, grinding, soldering, thawing pipe, torch applied roofing, and welding. Before doing any type of open flame or hot works operation, obtain a Hot Works Permit from the customer service representative in the particular zone where the work will be performed.
- B. All grinding, cutting, brazing, sweating, or welding operations carried on in the vicinity of, or accessible to combustible material, shall be adequately protected to make certain that a spark or hot slag does not reach the combustible material and start a fire.
- C. When it is necessary to do grinding, cutting, brazing, sweating or welding close to wood construction in pipe shafts or other locations where combustible materials cannot be removed or adequately protected, employ fireproof blankets and proper fire extinguishers. A helper shall be stationed nearby to guard against sparks and fire.
- D. Whenever combustible material has been exposed to molten metal or hot slag from welding or cutting operations or spatter from electric arc, a fireguard shall be kept at the

place of the hot work for at least one hour after completion to make sure that smoldering fires to not start.

- E. When welding or cutting in vertical pipe shaft or floor opening, a fireguard shall examine all floors below the welding or cutting operation. The fireguard shall be kept on duty for at least one hour after completion of work to guard against fires.

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 mechanical 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 mechanical items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 8 Section "Access Doors and Frames."

1.12 STARTUP/COMMISSIONING

- A. The building HVAC systems shall be commissioned in accordance with the latest edition of the ASHRAE document, "Guideline for Commissioning of HVAC Systems". Documentation and testing of these systems is required in cooperation with the Commissioning Authority. Project closeout is dependant on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Project Closeout, Division 1, for substantial completion details. Refer to Division 1 for detailed commissioning requirements.
- B. For purposes of implementing this guideline, the Commissioning Authority shall be defined as being a member of the University Staff.
- C. The contractor shall provide labor, material, and equipment required to facilitate the commissioning process as well as making adjustments and modifications needed to correct deficiencies in the operation of the equipment.
- D. The contractor shall submit copies of the service tickets to the commissioning authority during the one-year correction period. This step verifies that there are no unresolved deficiencies with the system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

- A. Refer to individual Division 23 piping Sections for special joining materials not listed below.
- B. 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.
- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
- G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- H. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.4 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 deg F.
 - 1. Manufacturers:
 - a. Capitol Manufacturing Co.
 - b. Central Plastics Company.
 - c. Eclipse, Inc.
 - d. Epco Sales, Inc.
 - e. Hart Industries, International, Inc.
 - f. Watts Industries, Inc.; Water Products Div.
 - g. Zurn Industries, Inc.; Wilkins Div.
- D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
 - 1. Manufacturers:
 - a. Capitol Manufacturing Co.
 - b. Central Plastics Company.
 - c. Epco Sales, Inc.
 - d. Watts Industries, Inc.; Water Products Div.
- 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. Manufacturers:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Central Plastics Company.
 - d. Pipeline Seal and Insulator, Inc.
 - 2. 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 deg F.
 - 1. Manufacturers:

- a. Calpico, Inc.
 - b. Lochinvar Corp.
- 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 deg F.
- 1. Manufacturers:
 - a. Perfection Corp.
 - b. Precision Plumbing Products, Inc.
 - c. Sioux Chief Manufacturing Co., Inc.
 - d. Victaulic Co. of America.

2.5 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.
- C. One-Piece, Cast-Brass Type: With set screw.
 - 1. Finish: Polished chrome-plated and rough brass.
- D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.
 - 1. Finish: Polished chrome-plated and rough brass.
- E. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.
- F. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw or spring clips, and chrome-plated finish.
- G. One-Piece, Floor-Plate Type: Cast-iron floor plate.
- H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.6 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 MECHANICAL DEMOLITION

- A. Refer to Division 2 Sections "Cutting and Patching" and "Selective Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove mechanical systems, equipment, and components indicated to be removed.
 - 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - 2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
 - 3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
 - 4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
 - 5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - 6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 - 7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 CUTTING AND PATCHING

- A. General: Comply with Division 2 Section "Cutting and Patching" for general cutting and patching procedures.
- B. Core drilling, cutting and patching, required for the installation of mechanical equipment as shown on the drawings and/or specified in Division 23 shall be the responsibility of this Contractor except where specifically stated otherwise. Only workers that are experienced, skilled, and licensed for the particular type of work involved, shall perform cutting and patching.
 - 1. Hanger inserts and pipe sleeves to be incorporated into the general building construction shall be furnished and installed by Contractor in ample time to avoid delaying the work of other trades or causing unnecessary cutting and patching work. Should any cutting be required to set inserts or sleeves, it shall be performed by Contractor using proper skilled tradesmen for the material involved, such as a bricklayer for masonry wall patching, etc.
 - 2. Core drilling shall be used where practical. Reasonable care shall be exercised during cutting to keep patching at a minimum.

3. Under no circumstances shall any cutting or burning of the structural parts of the building be undertaken without authority of Engineer.
4. When identical patching materials are not available for exteriors of historic buildings, submit alternate materials for review with the University Architects Office.

3.3 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 23 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 Coordination Drawings.
- 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 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. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 1. New and existing piping to remain: Use the following
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
 - c. Insulated Piping: One-piece, stamped-steel type with spring clips.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.

- e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.
 - f. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed or exposed-rivet hinge and set screw.
 - g. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw .
 - h. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type. Install sleeves for pipes passing through concrete and masonry walls, gypsum board partitions, and concrete floor and roof slabs.
- M. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 7 Section "Firestopping" for materials.
- N. Verify final equipment locations for roughing-in.
- O. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.
- P. Provide non-ferrous piping, ductwork, specialties, accessories, and supports in all magnet areas where indicated on plans.

3.4 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.
- 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. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. 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.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.5 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.

3.6 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 mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- D. Install equipment to allow right of way for piping installed at required slope.

3.7 PAINTING

- A. Piping, ducts, radiation, grilles, diffusers and other equipment that is furnished and installed under Division 23 and is exposed in finished spaces will be painted under Division 9 of the Specifications.
- B. Painting of exposed piping, ducts and other equipment in equipment spaces and accessible tunnels, crawl spaces, shafts, and other unfinished spaces, including painting of canvas jacketed pipe insulation, shall be completed by this Contractor.
- C. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.8 CONCRETE BASES

- A. The concrete work, including formwork and setting of anchor bolts and sleeves, is specified in other sections. Contractor shall be responsible for providing an accurate drawing of each equipment base required with the location of each anchor bolt properly dimensioned, and before the concrete is placed, the Contractor shall check and approve the formwork and placement of the anchor bolts.

- B. Contractor shall furnish anchor bolt and sleeve assemblies for all concrete equipment bases required in connection with the work under this Contract. Anchor bolts and sleeves shall be of approved material, size and shape. Inside diameter of sleeves shall be at least 2-1/2 times the bolt diameter.
- C. After Contractor has set and leveled the equipment, he shall be responsible for furnishing and proper placing of non-shrink grout for each base with 1 inch nominal thickness between the top of the concrete base and the bottom of the equipment base. Leveling of equipment and grouting shall be in strict accordance with manufacturer's recommendations and instructions of Owner's Construction Representative.

3.9 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 5 Section "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.10 GROUTING

- A. Mix and install grout for mechanical 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 23 0513

HVAC MOTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes basic requirements for factory-installed and field-installed motors.
- B. Related Sections include the following:
 - 1. Division 23 Sections for application of motors and reference to specific motor requirements for motor-driven equipment.

1.3 DEFINITIONS

- A. **Factory-Installed Motor:** A motor installed by motorized-equipment manufacturer as a component of equipment.
- B. **Field-Installed Motor:** A motor installed at Project site and not factory installed as an integral component of motorized equipment.

1.4 QUALITY ASSURANCE

- A. **Testing Agency Qualifications:** An independent testing agency, acceptable to authorities having jurisdiction, with the experience and capability to conduct the testing indicated, as documented according to ASTM E 548.
- 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. Comply with NFPA 70.

1.5 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices. Provide motors that are:
 - 1. Compatible with the following:
 - a. Magnetic controllers.
 - b. Multispeed controllers.
 - c. Reduced-voltage controllers.

2. Designed and labeled for use with variable frequency controllers, and suitable for use throughout speed range without overheating.
3. Matched to torque and horsepower requirements of the load.
4. Matched to ratings and characteristics of supply circuit and required control sequence.

PART 2 - PRODUCTS

2.1 MOTOR REQUIREMENTS

- A. Motor requirements apply to factory-installed and field-installed motors except as follows:
 1. Different ratings, performance, or characteristics for a motor are specified in another Section.
 2. Manufacturer for a factory-installed motor requires ratings, performance, or characteristics, other than those specified in this Section, to meet performance specified.

2.2 MOTOR CHARACTERISTICS

- A. Motors 1/2 HP and Larger: Three phase.
- B. Motors Smaller Than 1/2 HP: Single phase.
- C. Frequency Rating: 60 Hz.
- D. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.
- E. Duty: Continuous duty at ambient temperature of 105 deg F and at altitude of 3300 feet above sea level.
- F. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
- G. Enclosure: Open dripproof unless otherwise noted.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Standard efficiency according to NEMA MG 1, Para. 12.59 and Table 12-10.
- C. Stator: Copper windings, unless otherwise indicated.
 1. Multispeed motors shall have separate winding for each speed.
- D. Rotor: Squirrel cage, unless otherwise indicated.

- E. Bearings: Double-shielded, prelubricated ball bearings suitable for radial and thrust loading.
- F. Temperature Rise: Match insulation rating, unless otherwise indicated.
- G. Insulation: Class F, unless otherwise indicated.
- H. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or G.
 - 2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.
- I. Enclosure: Cast iron for motors 7.5 hp and larger; rolled steel for motors smaller than 7.5 hp.
 - 1. Finish: Gray enamel.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Reduced-Inrush Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Designed with critical vibration frequencies outside operating range of controller output.
 - 2. Temperature Rise: Matched to rating for Class B insulation.
 - 3. Insulation: Class H.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
 - 5. Motors to be controlled by variable speed drives shall be inverter spike resistant (ISR) rated.
- C. Rugged-Duty Motors: Totally enclosed, with 1.25 minimum service factor, greased bearings, integral condensate drains, and capped relief vents. Windings insulated with nonhygroscopic material.
 - 1. Finish: Chemical-resistant paint over corrosion-resistant primer.
- D. Source Quality Control: Perform the following tests on each motor according to NEMA MG 1:
 - 1. Measure winding resistance.
 - 2. Read no-load current and speed at rated voltage and frequency.
 - 3. Measure locked rotor current at rated frequency.
 - 4. Perform high-potential test.

2.5 SINGLE-PHASE MOTORS

- A. Type: One of the following, to suit starting torque and requirements of specific motor application:
 - 1. Capacitor start, capacitor run.
- B. Shaded-Pole Motors: For motors 1/20 hp and smaller only.
- C. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.
- D. Bearings: Ball type for belt-connected motors and other motors with high radial forces on motor shaft; sealed, prelubricated-sleeve type for other single-phase motors.

PART 3 - EXECUTION

3.1 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.
 - 2. Test interlocks and control features for proper operation.
 - 3. Verify that current in each phase is within nameplate rating.

3.2 ADJUSTING

- A. Align motors, bases, shafts, pulleys and belts. Tension belts according to manufacturer's written instructions.

3.3 CLEANING

- A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean motors, on completion of installation, according to manufacturer's written instructions.

END OF SECTION 23 0513

SECTION 23 0517

HVAC SLEEVES AND SLEEVE SEALS

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 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, Schedule 40, with plain ends and welded steel collar; zinc coated.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53, 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, provide products by one of the following:
1. Smith, Jay R. Mfg. Co.
 2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.
 3. <Insert manufacturer's name>.
- B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Advance Products & Systems, Inc.
 2. CALPICO, Inc.
 3. Metraflex Company (The).
 4. Pipeline Seal and Insulator, Inc.
 5. Proco Products, Inc.
- B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
1. Sealing Elements: EPDM-rubber or NBR 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 or Stainless steel of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

- A. Manufacturers: Subject to compliance with requirements, [provide products by one of the following:
1. Presealed Systems.
- 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, 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 Division 07 Section "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 Division 07 Section "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 Division 07 Section "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 Division 07 Section "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. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
 1. With the exception of floors of mechanical rooms, electrical rooms, or other wet areas, permanent sleeves are not required for core-drilled holes or for holes formed by removable PE sleeves.
 2. Sleeves are not required for pipes penetrating slabs on grade.
 3. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of kitchen areas, damp areas, or concealed under cabinets or laboratory equipment as well as mechanical equipment areas 2 inches above finished floor level and seal watertight. Extend sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - b. Exception: Sleeves through floor slabs in exposed areas such as classrooms, offices, and corridors shall extend ½ inch above the finished floor.

4. Install sleeves in new walls and slabs as new walls and slabs are constructed.
 5. Use the following sleeve materials for wall penetrations:
 - a. Steel Pipe Sleeves: For pipes penetrating interior masonry partitions and exterior building walls.
 - b. Galvanized Steel Sheet Sleeves: For pipes penetrating gypsum-board partitions.
 - (1) 22 gauge for sleeves up to 3 inches in diameter
 - (2) 16 gauge for sleeves larger than 3 inches.
 6. Use the following sleeve materials for slab penetrations:
 - a. Steel Pipe Sleeves: For pipes penetrating floor slabs in exposed areas such as classrooms offices and corridors.
 - b. Galvanized Steel Sheet Sleeves: Minimum of 16 gauge for sleeves through floor slabs for piping in chases, within walls, partitions, roof slabs and water closets.
 - c. 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. Refer to Division 7 Section "Sheet Metal Flashing and Trim" for flashing.
 - (1) Seal space outside of sleeve fittings with grout.
 - d. Where exposed covered piping passes through floor slabs in kitchen and hospital areas, the covering at floor shall be encased with an 18-gauge, stainless steel, cylindrical sleeve that is 6 inches high with lap joints fastened by two stainless steel metal screws.
 7. Seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 7 Section "Joint Sealants" for materials and installation.
- B. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. Install steel pipe for sleeves smaller than 6 inches in diameter.
 2. Install cast-iron "wall pipes" for sleeves 6 inches and larger in diameter.
 3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

END OF SECTION 23 0517

SECTION 23 0519

HVAC METERS AND GAGES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Bimetallic-actuated thermometers.
 - 2. Liquid-in-glass thermometers.
 - 3. Thermowells.
 - 4. Dial-type pressure gages.
 - 5. Gage attachments.
- B. Related Sections:
 - 1. Division 23 Section "Natural-Gas Piping" for gas meters.
 - 2. Division 23 Section "Steam and Condensate Heating Piping" for steam and condensate meters.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Wiring Diagrams: For power, signal, and control wiring.
- C. Product Certificates: For each type of meter and gage, from manufacturer.
- D. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 BIMETALLIC-ACTUATED THERMOMETERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Terice, H. O. Co.
- B. Standard: ASME B40.200.

- C. Case: Sealed type; stainless steel with 5-inch nominal diameter.
- D. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F.
- E. Connector Type(s): Union joint, adjustable angle, with unified-inch screw threads.
- F. Connector Size: 1/2 inch, with ASME B1.1 screw threads.
- G. Stem: 0.25 inch in diameter; stainless steel.
- H. Window: Plain glass.
- I. Ring: Stainless steel.
- J. Element: Bimetal coil.
- K. Pointer: Dark-colored metal.
- L. Accuracy: Plus or minus 1 percent of scale range.

2.2 LIQUID-IN-GLASS THERMOMETERS

- A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
 - 1. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - a. Flo Fab Inc.
 - b. Miljoco Corporation.
 - c. Palmer Wahl Instrumentation Group.
 - d. Tel-Tru Manufacturing Company.
 - e. Terrice, H. O. Co.
 - f. Weiss Instruments, Inc.
 - g. Winters Instruments - U.S.
 - 2. Standard: ASME B40.200.
 - 3. Case: Cast aluminum; 12-inch] 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.
 - 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, 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.

2.3 DUCT-THERMOMETER MOUNTING BRACKETS

- A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.4 THERMOWELLS

- A. Thermowells:
 1. Standard: ASME B40.200.
 2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
 3. Material for Use with Copper Tubing: Brass.
 4. Material for Use with Steel Piping: Carbon Steel.
 5. Type: Stepped shank unless straight or tapered shank is indicated.
 6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
 7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
 8. Bore: Diameter required to match thermometer bulb or stem.
 9. Insertion Length: Length required to match thermometer bulb or stem.
 10. Lagging Extension: Include on thermowells for insulated piping and tubing.
 11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.
- B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.5 PRESSURE GAGES

- A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMETEK, Inc.; U.S. Gauge.
 - b. Ashcroft Inc.: Type 1010
 - 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.
2. Standard: ASME B40.100.
 3. Case: Liquid-filled type(s); stainless steel 6-inch nominal diameter.
 4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 5. Pressure Connection: Brass, with NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 6. Movement: Mechanical, with link to pressure element and connection to pointer.
 7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
 8. Pointer: Dark-colored metal.
 9. Window: Glass or plastic.
 10. Ring: Stainless steel
 11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.6 GAGE ATTACHMENTS

- A. Snubbers: ASME B40.100, brass; with NPS 1/4, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.
- B. Siphons: Loop-shaped section of steel pipe with NPS 1/2 pipe threads.
- C. Valves: Stainless-steel needle, with NPS 1/2, ASME B1.20.1 pipe threads.

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 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.
- F. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.
- G. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
- H. Install valve and snubber in piping for each pressure gage for fluids (except steam).
- I. Install valve and syphon fitting in piping for each pressure gage for steam.
- J. Install thermometers in the following locations:
 - 1. Two inlets and two outlets of each chiller.
 - 2. Inlet and outlet of each hydronic coil in air-handling units.
 - 3. Two inlets and two outlets of each hydronic heat exchanger.
 - 4. Inlet and outlet of each fluid cooler.
 - 5. Outside-, return-, supply-, and mixed-air ducts.
 - 6. Where indicated on plans.
- K. Install pressure gages in the following locations:
 - 1. Discharge of each pressure-reducing valve.
 - 2. Inlet and outlet of each chiller chilled-water connection.
 - 3. Suction and discharge of each pump.
 - 4. Inlet and outlet of each hydronic heat exchanger.
 - 5. Inlet and outlet of each fluid cooler.
 - 6. Where indicated on drawings.

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. After installation, calibrate meters according to manufacturer's written instructions.
- B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

- A. Thermometers at inlets and outlets of each chiller shall be the following:
 - 1. Industrial-style, liquid-in-glass type.

- B. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be the following:
 - 1. Industrial-style, liquid-in-glass type.
- C. Thermometers at inlets and outlets of each fluid cooler shall be the following:
 - 1. Industrial-style, liquid-in-glass type.
- D. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be the following:
 - 1. Industrial-style, liquid-in-glass type.
- E. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

- A. Scale Range for Chilled-Water Piping: 0 to 100 deg F.
- B. Scale Range for Heat Recovery-Water Piping: 0 to 100 deg F.
- C. Scale Range for Heating, Hot-Water Piping: 0 to 200 deg F.
- D. Scale Range for HP Steam Piping: 50 to 500 deg F.
- E. Scale Range for HP Steam Piping: 20 to 240 deg F.
- F. Scale Range for Steam-Condensate Piping: 20 to 240 deg F.
- G. Scale Range for Air Ducts: Minus 40 to 160 deg F

3.6 PRESSURE-GAGE SCHEDULE

- A. Pressure gages on steam systems shall be the following:
 - 1. Ashcroft No. 1010 pressure gauge, 6 inch dial, with pigtail and Ashcroft No. 50-70016 gauge cock.
- B. Pressure gages at inlet and outlet of each chiller chilled-water, hydronic heat exchange and fluid cooler connection shall be the following:
 - 1. Liquid-filled direct-mounted, metal case.
- C. Pressure gages at suction and discharge of each pump shall be[**one of**] the following:
 - 1. Liquid-filled direct-mounted, metal case.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range for Chilled-Water Piping: 0 to 100 psi.
- B. Scale Range for Heat Recovery-Water Piping: 0 to 100 psi.
- C. Scale Range for Heating, Hot-Water Piping: 0 to 100 psi.
- D. Scale Range for LP Steam Piping: 0 to 30 psi.
- E. Scale Range for HP Steam Piping: 0 to 300 psi.

END OF SECTION 23 0519

SECTION 23 05 23

HVAC GENERAL-DUTY VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following general-duty valves:
 - 1. Copper-alloy ball valves.
 - 2. Ferrous-alloy ball valves.
 - 3. Ferrous-alloy butterfly valves.
 - 4. Bronze check valves.
 - 5. Cast steel check valves
 - 6. Spring-loaded, lift-disc check valves.
 - 7. Bronze gate valves.
 - 8. Cast steel gate valves.
 - 9. Bronze globe valves.
 - 10. Cast-iron globe valves.
 - 11. Cast steel globe valves.
- B. Related Sections include the following:
 - 1. Division 2 piping Sections for general-duty and specialty valves for site construction piping.
 - 2. Division 23 Section "HVAC Identification" for valve tags and charts.
 - 3. Division 23 Section "HVAC Instrumentation and Controls for HVAC " for control valves and actuators.
 - 4. Division 23 piping Sections for specialty valves applicable to those Sections only.

1.3 DEFINITIONS

- A. The following are standard abbreviations for valves:
 - 1. CWP: Cold working pressure.
 - 2. EPDM: Ethylene-propylene-diene terpolymer rubber.

3. NBR: Acrylonitrile-butadiene rubber.
4. PTFE: Polytetrafluoroethylene plastic.
5. SWP: Steam working pressure.
6. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS

- A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

1.5 QUALITY ASSURANCE

- A. ASME Compliance: ASME B31.1 for power piping valves and ASME B31.9 for building services piping valves.
 1. Exceptions: Domestic hot- and cold-water, sanitary waste, and storm drainage piping valves unless referenced.
- B. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

1.6 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, and globe valves closed to prevent rattling.
 4. Set ball and plug valves open to minimize exposure of functional surfaces.
 5. Set butterfly valves closed or slightly open.
 6. 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 VALVES, GENERAL

- A. Refer to Part 3 "Valve Applications" Article for applications of valves.
- B. Bronze Valves: NPS 2 and smaller with threaded ends, unless otherwise indicated.
- C. Ferrous Valves: NPS 2-1/2 and larger with flanged 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 pipe, unless otherwise indicated.
- F. Valve Actuators:
 - 1. Handwheel: For valves other than quarter-turn types.
 - 2. Lever Handle: For quarter-turn valves NPS 6 and smaller, except plug valves.
 - 3. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug head.
- G. Extended Valve Stems: On insulated valves.
- H. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.
- I. Valve Grooved Ends: AWWA C606.
 - 1. Solder Joint: With sockets according to ASME B16.18.
 - a. Caution: Use solder with melting point below 840 deg F for angle, check, gate, and globe valves; below 421 deg F for ball valves.
 - 2. Threaded: With threads according to ASME B1.20.1.
- J. Valve Bypass and Drain Connections: MSS SP-45.

2.2 GATE VALVES

- A. Manufacturers:
 - 1. Subject to compliance with requirements, provide products by the manufacturers specified.
 - a. Bonney Forge
 - b. Crane Company; Valves and Fitting Division.
 - c. Hammond Valve Corporation.
 - d. Milwaukee Valve Company, Inc.
 - e. NIBCO INC.
 - f. Vogt Valves
- B. Valves used for chilled water and heating water shall be the following.

- C. University of Minnesota Requirement: The valve specifications for paragraphs 1 and 3 below are based on Division 15 section 15050 section 10 paragraphs 10.3.1.1 and 10.3.1.2 of the 2002 Standards. Delete paragraphs 2 and 4 below and retain paragraphs 1 and 3 for University projects. Valve pressure class listed is a minimum requirement. Higher pressure class valves may be required depending on the application.
1. NPS 2 and Smaller: MSS SP-80, Class 150 (150 psig SWP, 300 psig CWP), ASTM B 62 cast bronze body with bronze union ring bonnet, rising stem, solid bronze wedge, with carbon steel or malleable-iron hand wheel, and threaded ends.
 2. NPS 2-1/2 and Larger: MSS SP-70, ANSI Class 150, ASTM A 216 cast-steel body with bolted bonnet, rising stem, outside screw and yoke, solid wedge, 2-piece packing gland assembly, with carbon steel hand wheel, and flanged end connections.
- D. Valves used for low-pressure steam (15 psi and below) shall be the following.
- E. University of Minnesota Requirement: The valve specifications for paragraphs 1 and 3 below are based on Division 15 section 15050 section 10 paragraphs 10.3.2.1 and 10.3.2.2 of the 2002 Standards. Delete paragraphs 2 and 4 below and retain paragraphs 1 and 3 for University projects.
1. NPS 2 and Smaller: Class 800, forged steel body with welded bonnet, rising stem, outside screw and yoke, stainless steel seat rings, solid wedge, self-aligning two piece packing gland, with carbon steel or malleable-iron hand wheel, and threaded or welded ends.
 2. NPS 2-1/2 and Larger: MSS SP-70, ANSI Class 150, ASTM A 216 cast-steel body with bolted bonnet, rising stem, outside screw and yoke, solid wedge, 2-piece packing gland assembly, with carbon steel hand wheel, and flanged end connections.

2.3 BUTTERFLY VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified
1. Butterfly valves for water service:
 - a. Bray International, Inc.
 - b. Crane Company; Valves and Fitting Division.
 - c. Hammond Valve Corporation.
 - d. Milwaukee Valve Company, Inc.
 - e. Mueller Steam Specialty.
 - f. NIBCO INC.
 - g. Watts Industries, Inc.; Water Products Div.
 2. Butterfly valves for high pressure steam service:
 - a. Tyco International, Ltd.; Vanessa Series 30,000

- B. University of Minnesota Requirement: The valve specification in paragraph B below is based on Division 15 section 15050 section 10 paragraph 10.4.1 of the 2002 Standards. Valve pressure class listed is a minimum requirement. Higher pressure class valves may be required depending on the application. The valve specified in section B may only be used for compressed air, chilled water, condenser water, potable and non-potable water. The use of butterfly valves in heating water service above 150°F is not allowed per paragraph 10.4.1. Delete section C below and retain section B for University projects.
- C. Valves used for chilled water shall be the following. The use of butterfly valves in heating water service above 150°F is prohibited.
 - 1. NPS 2-1/2 and Larger: MSS SP-67, 250 psig CWP rating, ASTM A 126 Class B cast iron body with 316 stainless steel shaft and disc, one or two piece stem, field replaceable EPDM seat and seals, extended neck, full lug style with ANSI Class 125 or 150 compatible flanges. Valve seat shall be bubble tight and suitable for 200-psig dead end service.
 - a. Operator for Sizes 2-1/2 Inches to 6 Inches: Standard lever handle with 10-position stop plate and memory stop. Handle shall be pad lockable where installed in areas accessible to the public.

2.4 BALL VALVES

- A. Manufacturers:
 - 1. Subject to compliance with requirements, provide products by the manufacturers specified:
 - a. American Valve, Inc.
 - b. Conbraco Industries, Inc.; Apollo Division.
 - c. Hammond Valve Corporation.
 - d. Milwaukee Valve Company, Inc.
 - e. NIBCO Inc.
 - f. Stockham Valves & Fittings, Inc.
- B. Valves used for chilled water and heating water shall be the following.
 - 1. NPS 2 and Smaller: MSS SP-110, Class 150 (150 psig SWP, 600 psig CWP), ASTM B 584 cast bronze body and packing nut, with full port, two-piece construction, 316 stainless steel ball and blowout proof stem, packing nut design, reinforced Teflon seats and seals, ferrous alloy vinyl covered handle, and threaded end connections. Provide memory stop where used in balancing applications. Handle shall be pad lockable where installed in areas accessible to the public.
 - 2. NPS 2-1/2 through NPS 6: MSS SP-72, Class 125 (125 psig SWP, 200 psig CWP), ASTM A 126 Class B cast iron body with full port, two-piece bolted construction, cast iron Teflon fused ball, stainless steel blowout proof stem, reinforced Teflon seats and seals, steel rubber covered handle, and flanged end connections. Provide memory stop where used in balancing applications. Handle shall be pad lockable where installed in areas accessible to the public.

2.5 GLOBE VALVES

A. Manufacturers:

1. Subject to compliance with requirements, provide products by the manufacturers specified:
 - a. Cincinnati Valve Co.
 - b. Crane Co.; Crane Valve Group; Crane Valves.
 - c. Crane Co.; Crane Valve Group; Jenkins Valves.
 - d. Crane Co.; Crane Valve Group; Stockham Div.
 - e. Grinnell Corporation.
 - f. Hammond Valve.
 - g. Kitz Corporation of America.
 - h. Legend Valve & Fitting, Inc.
 - i. Milwaukee Valve Company.
 - j. NIBCO INC.
 - k. Powell, Wm. Co.
 - l. Red-White Valve Corp.
 - m. Walworth Co.

B. Valves used for chilled water and heating water shall be the following.

1. NPS 2 and Smaller: MSS SP-80, Class 150 (150 psig WSP, 300 psig CWP), ASTM B 62 cast bronze body with bronze union ring bonnet, rising stem, stainless steel seat ring and disc, with carbon steel or malleable-iron hand wheel, and threaded ends.
2. NPS 2-1/2 and Larger: MSS SP-85, ANSI Class 150, ASTM A 216 cast-steel body with bolted bonnet, rising stem, outside screw and yoke, renewable stainless steel seat ring and disc, with carbon steel or malleable-iron hand wheel, and flanged end connections.

C. Valves used for low-pressure steam (15 psi and below) shall be the following.

1. NPS 2 and Smaller: Class 800, forged steel body with welded bonnet, rising stem, outside screw and yoke, renewable stainless steel seat ring and disc, with carbon steel or malleable-iron hand wheel, and threaded ends.
2. NPS 2-1/2 and Larger: MSS SP-85, ANSI Class 150, ASTM A 216 cast-steel body with bolted bonnet, rising stem, outside screw and yoke, renewable stainless steel seat ring and disc, with carbon steel or malleable-iron hand wheel, and flanged end connections.

2.6 CHECK VALVES

A. Manufacturers:

1. Subject to compliance with requirements, provide products by the manufacturers specified:
 - a. American Valve, Inc.
 - b. Cincinnati Valve Co.
 - c. Crane Co.; Crane Valve Group; Crane Valves.
 - d. Crane Co.; Crane Valve Group; Jenkins Valves.
 - e. Crane Co.; Crane Valve Group; Stockham Div.
 - f. Grinnell Corporation.
 - g. Hammond Valve.
 - h. Kitz Corporation of America.
 - i. Legend Valve & Fitting, Inc.
 - j. Milwaukee Valve Company.
 - k. NIBCO INC.
 - l. Powell, Wm. Co.
 - m. Red-White Valve Corp.
 - n. Walworth Co.
 - o. Watts Industries, Inc.; Water Products Div.

- B. Valves used for low-pressure condensate (below 15 psig), chilled water, heating water, and condenser water, and glycol shall be the following. The use of spring check valves in low or high-pressure steam service is prohibited
 1. Swing Check Valves, NPS 2 and Smaller: MSS SP-80, Class 150 (150 psig SWP, 300 psig CWP), ASTM B 62 cast bronze body with threaded bonnet, full port construction, with Teflon disc, bronze seat, and threaded end connections.
 2. Spring Check Valves, NPS 2 and Smaller: Class 150 (150 psig SWP, 300 psig CWP), ASTM B 62 cast bronze body, two piece construction, with EPDM seal, stainless steel stem and disc, and threaded end connections.
 3. Swing Check Valves, NPS 2-1/2 and Larger: MSS SP-71, ANSI Class 150, ASTM A 216 cast-steel body with bolted bonnet, replaceable composition disc, and flanged end connections.
 4. Spring Check Valves, NPS 2-1/2 and Larger: ANSI Class 150, ASTM A 126 Class B cast-iron body, with stainless steel trim and spring, wafer style with ANSI Class 125 or 150 compatible casting.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. 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.
- C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- D. Examine threads on valve and mating pipe for form and cleanliness.
- E. 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.
- F. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE APPLICATIONS

- A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:
 1. Shutoff Service: Ball, butterfly, or gate valves.
 2. Throttling Service: Ball, butterfly, or globe valves.
 3. Pump Discharge: Spring-loaded, lift-disc check valves.
- B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.

3.3 VALVE INSTALLATION

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- C. Locate valves for easy access and provide separate support where necessary.
- D. Install valves in horizontal piping with stem at or above center of pipe.
- E. Install valves in position to allow full stem movement.
- F. Install check valves for proper direction of flow and as follows:
 1. Swing Check Valves: In horizontal position with hinge pin level.
 2. Dual-Plate Check Valves: In horizontal or vertical position, between flanges.
 3. Lift Check Valves: With stem upright and plumb.

3.4 JOINT CONSTRUCTION

- A. Refer to Division 23 Section "HVAC Materials and Methods" for basic piping joint construction.
- B. Grooved Joints: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.
- C. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.5 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.

END OF SECTION 23 05 23

SECTION 23 0529

HVAC HANGERS AND SUPPORTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes hangers and supports for mechanical system piping and equipment.
- B. Related Sections include the following:
 - 1. Division 5 Section "Metal Fabrications" for materials for attaching hangers and supports to building structure.

1.3 DEFINITIONS

- A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry.
- B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

- A. Design channel support systems for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
- B. Design heavy-duty trapezes for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

1.5 SUBMITTALS

- A. Product Data: For each type of pipe hanger, channel support system component, and thermal-hanger shield insert indicated.
- B. Welding Certificates: Copies of certificates for welding procedures and operators.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Pipe Hangers:
 - a. Globe Pipe Hanger Products, Inc.
 - b. Grinnell Corp.
 - c. Michigan Hanger Co., Inc.
 - d. National Pipe Hanger Corp.
 - e. PHD Manufacturing, Inc.
 - f. Piping Technology & Products, Inc.
2. Channel Support Systems:
 - a. Grinnell Corp.; Power-Strut Unit.
 - b. Michigan Hanger Co., Inc.; O-Strut Div.
 - c. National Pipe Hanger Corp.
 - d. Thomas & Betts Corp.
 - e. Unistrut Corp.
3. Thermal-Hanger Shield Inserts:
 - a. Carpenter & Patterson, Inc.
 - b. Michigan Hanger Co., Inc.
 - c. PHS Industries, Inc.
 - d. Pipe Shields, Inc.
4. Powder-Actuated Fastener Systems:
 - a. Gunnebo Fastening Corp.
 - b. Hilti, Inc.
 - c. ITW Ramset/Red Head.
 - d. Masterset Fastening Systems, Inc.
5. Non-Metallic Strut, Pipe Hangers and Support Systems
 - a. Aickinstrut: An Allied Tube and Conduit Company
 - b. Champion Fiberglass, Inc.
 - c. Cooper B-Line, Inc.

2.2 MANUFACTURED UNITS

- A. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated components. Refer to "Hanger and Support Applications" Article in Part 3 for where to use specific hanger and support types.
 1. Galvanized, Metallic Coatings: For piping and equipment that will not have field-applied finish.
 2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

- B. Thermal-Hanger Shield Inserts: 100-psi minimum compressive-strength insulation, encased in sheet metal shield.
 - 1. Material for Cold Piping: ASTM C 552, Type I cellular glass or water-repellent-treated, ASTM C 533, Type I calcium silicate with vapor barrier.
 - 2. Material for Hot Piping: ASTM C 552, Type I cellular glass or water-repellent-treated, ASTM C 533, Type I calcium silicate.
 - 3. For Trapeze or Clamped System: Insert and shield cover entire circumference of pipe.
 - 4. For Clevis or Band Hanger: Insert and shield cover lower 180 degrees of pipe.
 - 5. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.3 MISCELLANEOUS MATERIALS

- A. Powder-Actuated Drive-Pin Fasteners: Powder-actuated-type, drive-pin attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.
- C. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.
- D. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged, nonshrink and nonmetallic, dry, hydraulic-cement grout.
 - 1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.
 - 2. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 3. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger requirements are specified in Sections specifying equipment and systems.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Specification Sections.
- C. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
 - 1. Adjustable Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.-
 - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.

3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
6. Adjustable Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
7. Adjustable Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
9. Adjustable Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2 (DN15 to DN50).
10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
12. U-Bolts (MSS Type 24): For support of heavy pipe, NPS 1/2 to NPS 30.
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24, if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30, if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
 22. Clevis hangers are not allowed on steam lines over 15 psig.
- D. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Specification 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.
- E. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- F. Minimum Hanger-Rod Diameters: Unless otherwise indicated and except as specified in piping system Specification Sections, the minimum hanger rod diameters for piping supports shall be as followings:
1. For pipe sizes, up to NPS 2, use 3/8 inch.
 2. For pipe sizes, from NPS 2-1/2 to NPS 3-1/2, use 1/2 inch.
 3. For pipe sizes, from NPS 4 to NPS 5, use 5/8 inch.
 4. For pipe size NPS 6, use 3/4 inch.
 5. For pipe sizes, from NPS 8 to NPS 12, use 7/8 inch.
- G. Building Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction to attach to top flange of structural shape.

3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where head room is limited.
- H. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Specification 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 by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe, 360-degree insert of high-density, 100-psi minimum compressive-strength, water-repellent-treated calcium silicate or cellular-glass pipe insulation, same thickness as adjoining insulation with vapor barrier and encased in 360-degree sheet metal shield.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Pipe Hanger and Support 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. Vertical-Piping Clamp Installation: Unless otherwise indicated and except as specified in piping system Specification Sections, install riser clamps to support vertical risers at every floor.
- C. Channel Support System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems.
 - 1. Field assemble and install according to manufacturer's written instructions.
- D. Heavy-Duty Steel Trapeze Installation: Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated, heavy-duty trapezes.
 - 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, steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.
- E. Install building attachments within concrete slabs or attach to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, and expansion joints, 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.
- F. Install powder-actuated drive-pin fasteners 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.
- G. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- H. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- I. 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.
- 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 so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping," is not exceeded.
- L. 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.
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 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.
5. Insert Material: Length at least as long as protective shield.
6. 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 above or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

3.4 METAL FABRICATION

- A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes 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 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 contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

- A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

3.6 PAINTING

- A. Touching Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9 Section "Painting."
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 23 0540

SECTION 23 05 48

VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Isolation pads.
 - 2. Isolation mounts.
 - 3. Restrained elastomeric isolation mounts.
 - 4. Freestanding and restrained spring isolators.
 - 5. Housed spring mounts.
 - 6. Restrained vibration isolation roof-curb rails.
 - 7. Restraining braces and cables.
 - 8. Steel and inertia vibration isolation equipment bases.

1.3 DEFINITIONS

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.
- C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 PERFORMANCE REQUIREMENTS

- A. Wind-Restraint Loading:
 - 1. Building Classification Category: [I] [II] [III] [IV].
 - 2. Minimum 10 lb/sq. ft. multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

1.5 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.
 - 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. Field quality-control test reports.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of 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.
- 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 neoprene.
- 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.
- E. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig.
 6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
- F. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 2. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.
 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.

2.2 VIBRATION ISOLATION EQUIPMENT BASES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Amber/Booth Company, Inc.
 2. California Dynamics Corporation.

3. Isolation Technology, Inc.
 4. Kinetics Noise Control.
 5. Mason Industries.
 6. Vibration Eliminator Co., Inc.
 7. Vibration Isolation.
 8. Vibration Mountings & Controls, Inc.
- B. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
 - a. Include supports for suction and discharge elbows for pumps.
 2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. 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.

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 control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation 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 VIBRATION-CONTROL DEVICE INSTALLATION

- A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- B. Equipment Restraints:
 - 1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
- C. Install cables so they do not bend across edges of adjacent equipment or building structure.
- D. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- E. 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.
- F. 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.
- G. 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.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. 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. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Prepare test and inspection reports.

3.4 ADJUSTING

- A. 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.
- B. Adjust active height of spring isolators.
- C. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 230548

SECTION 23 0553

HVAC IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following mechanical identification materials and their installation:
 1. Equipment nameplates.
 2. Equipment markers.
 3. Equipment signs.
 4. Access panel and door markers.
 5. Pipe markers.
 6. Duct markers.
 7. Stencils.
 8. Valve tags.
 9. Valve schedules.
 10. Warning tags.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Valve numbering scheme.
- C. Valve Schedules: For each piping system. Furnish extra copies (in addition to mounted copies) to include in maintenance manuals.

1.4 QUALITY ASSURANCE

- A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

1.5 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 location of access panels and doors.

- C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION DEVICES

- A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.
1. Data:
 - a. Manufacturer, product name, model number, and serial number.
 - b. Capacity, operating and power characteristics, and essential data.
 - c. Labels of tested compliances.
 2. Location: Accessible and visible.
 3. Fasteners: As required to mount on equipment.
- B. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.
1. Terminology: Match schedules as closely as possible.
 2. Data:
 - a. Name and plan number.
 - b. Equipment service.
 - c. Design capacity.
 - d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.
 3. Size: 2-1/2 by 4 inches for control devices, dampers, and valves; 4-1/2 by 6 inches for equipment.
- C. Equipment Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.
1. Data: Instructions for operation of equipment and for safety procedures.
 2. Engraving: Manufacturer's standard letter style, of sizes and with terms to match equipment identification.
 3. Thickness: 1/16 inch for units up to 20 sq. in. or 8 inches in length, and 1/8 inch for larger units.
 4. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.
- D. Access Panel and Door Markers: 1/16-inch- thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch center hole for attachment.

1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.2 PIPING IDENTIFICATION DEVICES

- A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.
 1. Colors: Comply with Table 2.2a Piping Identification Application Schedule below. If service type is not listed, colors shall comply ASME A13.1.
 2. Lettering: Use piping system terms indicated in table below.
 3. Lettering Size: Letters shall have a minimum height of 1 inch.
 4. Pipes with OD, Including Insulation, Less Than 6 Inches: Full-band pipe markers extending 360 degrees around pipe at each location.
 5. Pipes with OD, Including Insulation, 6 Inches and Larger: Either full-band or strip-type pipe markers at least three times letter height and of length required for label.
 6. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow. Arrow color shall be black.
- B. Pretensioned Pipe Markers: Precoiled semirigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.
- C. Shaped Pipe Markers: Preformed semirigid plastic formed to partially cover circumference of pipe and to attach to pipe with mechanical fasteners that do not penetrate insulation vapor barrier.
- D. Self-Adhesive Pipe Markers: Plastic with pressure-sensitive, permanent-type, self-adhesive back.
- E. Plastic Tape: Continuously printed, vinyl tape at least 3 mils thick with pressure-sensitive, permanent-type, self-adhesive back.
 1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: 3/4 inch minimum.
 2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

Table 2.2a Piping Identification Application Schedule:

Service	Band	Background Letters	Legend
Chilled Water Return	Green	Black	C.H.R
Chilled Water Supply	Green	Black	C.H.S.
Heating Water Return	Yellow	Black	H.W.S.
Heating Water Supply	Yellow	Black	H.W.R.
Low Pressure Condensate	Yellow	Black	LPC
Low Pressure Steam	Yellow	Black	LPS

2.3 DUCT IDENTIFICATION DEVICES

- A. Duct Markers: Engraved, color-coded laminated plastic. Include direction and quantity of airflow and duct service (such as supply, return, and exhaust). Include contact-type, permanent adhesive.

2.4 STENCILS

- A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door markers, equipment markers, equipment signs, and similar operational instructions.
1. Stencil Paint: Exterior, gloss, acrylic enamel black, unless otherwise indicated. Paint may be in pressurized spray-can form.
 2. Identification Paint: Exterior, acrylic enamel in colors according to ASME A13.1, unless otherwise indicated.

2.5 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers. Provide 5/32-inch hole for fastener.
1. Material: 19 gauge brass or 0.032 inch aluminum.
 2. Valve-Tag Fasteners: Brass "S" hooks or beaded chain.

2.6 VALVE SCHEDULES

- A. Valve Schedules: For each piping system, on standard-size bond paper. Tabulate valve number (corresponding to valve numbers on drawings and control diagrams and sequences of operation), piping system, system abbreviation (as shown on valve tag), location of valve (room or space corresponding to room numbers on architectural floor plans), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
1. Valve-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.
 2. Frame: Finished hardwood.
 3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

2.7 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 APPLICATIONS, GENERAL

- A. Products specified are for applications referenced in other Division 15 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.2 EQUIPMENT IDENTIFICATION

- A. Install and permanently fasten equipment nameplates on each major item of HVAC equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:
1. Fuel-burning units, including boilers, furnaces, heaters, stills, and absorption units.
 2. Pumps, compressors, chillers, condensers, and similar motor-driven units.
 3. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
 4. Fans, blowers, primary balancing dampers, and mixing boxes.
 5. Packaged HVAC central-station and zone-type units.
- B. Install equipment markers with permanent adhesive on or near each major item of HVAC equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.
1. Letter Size: Minimum 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.
 2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
 3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:
 - a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
 - b. Meters, gages, thermometers, and similar units.
 - c. Fuel-burning units, including boilers, furnaces, heaters, stills, and absorption units.
 - d. Pumps, compressors, chillers, condensers, and similar motor-driven units.
 - e. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
 - f. Fans, blowers, primary balancing dampers, and mixing boxes.

- g. Packaged HVAC central-station and zone-type units.
 - h. Tanks and pressure vessels.
 - i. Strainers, filters, humidifiers, water-treatment systems, and similar equipment.
- C. Stenciled Equipment Marker Option: Stenciled markers may be provided instead of laminated-plastic equipment markers, at Installer's option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.
- D. Install equipment signs with screws or permanent adhesive on or near each major item of mechanical equipment. Locate signs where accessible and visible.
 - 1. Identify HVAC equipment with equipment markers in the following color codes:
 - a. Green: For cooling equipment and components.
 - b. Yellow: For heating equipment and components.
 - 2. Letter Size: Minimum 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.
 - 3. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
 - 4. Include signs for the following general categories of equipment:
 - a. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
 - b. Pumps, compressors, chillers, condensers, and similar motor-driven units.
 - c. Heat exchangers, coils, evaporators, cooling towers, heat recovery units, and similar equipment.
 - d. Fans, blowers, primary balancing dampers, and mixing boxes.
 - e. Packaged HVAC central-station and zone-type units.
 - f. Tanks and pressure vessels.
 - g. Strainers, filters, humidifiers, water-treatment systems, and similar equipment.
- E. Stenciled Equipment Sign Option: Stenciled signs may be provided instead of laminated-plastic equipment signs, at Installer's option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.
- F. Install access panel markers with screws on equipment access panels.

3.3 PIPING IDENTIFICATION

- A. Install manufactured pipe markers indicating service on each piping system. Install with black flow indication arrows showing direction of flow.
 - 1. Pipes with OD, Including Insulation, Less Than 6 Inches: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 1-1/2 inches wide, lapped at least 1-1/2 inches at both ends of pipe marker, and covering full circumference of pipe.
 - 2. Pipes with OD, Including Insulation, 6 Inches and Larger: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 1-1/2 inches wide, lapped at least 3 inches at both ends of pipe marker, and covering full circumference of pipe.
- B. Stenciled Pipe Marker Option: Stenciled markers may be provided instead of manufactured pipe markers, at Installer's option. Install stenciled pipe markers with painted, color-coded bands or rectangles on each piping system.
 - 1. Identification Paint: Use for contrasting background.
 - 2. Stencil Paint: Use for pipe marking.
- C. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed 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 nonaccessible 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. Spaced at maximum intervals of 20 feet and at every change in direction.
 - 8. On piping above removable acoustical ceilings. Omit intermediately spaced markers.

3.4 DUCT IDENTIFICATION

- A. Install duct markers with permanent adhesive on air ducts in the following color codes:
 - 1. Green: For cold-air supply ducts.
 - 2. Yellow: For hot-air supply ducts.
 - 3. Blue: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
 - 4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

5. Letter Size: Minimum 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.
- B. Stenciled Duct Marker Option: Stenciled markers, showing service and direction of flow, may be provided instead of laminated-plastic duct markers, at Installer's option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.
- C. Locate markers near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Each steam trap shall be tagged with a triangular stainless steel tag that contains the number of the trap. The university shall provide the contractor with a sequence of numbers to be used in numbering the traps.
- C. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following:
 1. Valve-Tag Size and Shape:
 - a. Gas: 1-1/2 inches square.
 - b. Chilled Water: 1 1/2 inches square.
 - c. Heating Water & Glycol: 1 1/2 inches square
 - d. Steam: 1-1/2 inches square.
 - e. Steam Traps: Triangular 1-1/2 inches each side.
 2. Valve-Tag Color:
 - a. Gas: Yellow.
 - b. Chilled Water: Green.
 - c. Heating Water & Glycol: Yellow
 - d. Steam: Yellow.
 - e. Steam Traps: Stainless.
 3. Letter Color:
 - a. Gas: Black.
 - b. Chilled Water: White.
 - c. Heating Water & Glycol: Black

- d. Steam: Black
- e. Steam Traps: Lettering shall be stamped.

3.6 VALVE-SCHEDULE INSTALLATION

- A. Mount valve schedule on wall in accessible location in each major equipment room.

3.7 WARNING-TAG INSTALLATION

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

3.8 ADJUSTING

- A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.9 CLEANING

- A. Clean faces of mechanical identification devices and glass frames of valve schedules.

END OF SECTION 23 0553

SECTION 23 0593

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Balancing Air Systems:
 - a. Constant-volume air systems.
 - b. Variable-air-volume systems.
 - 2. Balancing Hydronic Piping Systems:
 - a. Variable-flow hydronic systems.

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 entity engaged to perform TAB Work.

1.4 SUBMITTALS

- A. Qualification Data: Within 45 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 45 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.
- C. Strategies and Procedures Plan: Within 30 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
- D. Certified TAB reports.
- E. Sample report forms.
- F. 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.

1.5 QUALITY ASSURANCE

- A. TAB Contractor Qualifications: Engage a TAB entity certified by NEBB or TABB.
 1. TAB Field Supervisor: Employee of the TAB contractor.
 2. TAB Technician: Employee of the TAB contractor.
- B. TAB Conference: Meet with Engineer, Owner, and Commissioning Authority on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide seven days' advance notice of scheduled meeting time and location.
 1. Agenda Items:
 - a. The Contract Documents examination report.
 - b. The TAB plan.
 - c. Coordination and cooperation of trades and subcontractors.
 - d. Coordination of documentation and communication flow.
- C. Certify TAB field data reports and perform the following:
 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.
- D. TAB Report Forms: Use standard TAB contractor's forms approved by Engineer.
- E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

1.6 PROJECT 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.

1.7 COORDINATION

- A. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

- B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.1 TAB SPECIALISTS

- A. Subject to compliance with requirements, engage one of the following TAB Contractors:
 - 1. Bal-tech, Inc.
 - 2. Systems Management & Balancing of Minnesota.

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 systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are 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 supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Division 23 Section "Metal Ducts" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- F. Examine equipment performance data including fan and pump curves.
 - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.

- I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
- K. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.
- L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.
- M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- N. Examine system pumps to ensure absence of entrained air in the suction piping.
- O. Examine operating safety interlocks and controls on HVAC equipment.
- P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.3 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures.
- B. Complete system-readiness checks and prepare reports. Verify the following:
 - 1. Permanent electrical-power wiring is complete.
 - 2. Hydronic systems are filled, clean, and free of air.
 - 3. Automatic temperature-control systems are operational.
 - 4. Equipment and duct access doors are securely closed.
 - 5. Balance, smoke, and fire dampers are open.
 - 6. Isolating and balancing valves are open and control valves are operational.
 - 7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
 - 8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.
 - 1. Comply with requirements in ASHRAE 62.1-2004, Section 7.2.2, "Air Balancing."
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 2. After testing and balancing, install test ports and duct access doors that comply with requirements in Division 23 Section "Air Duct Accessories."
 3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section "HVAC 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 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' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Division 23 Section "Metal Ducts."

3.6 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. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:
 - a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
 - b. Measure static pressure directly at the fan outlet or through the flexible connection.
 - c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
 - d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
 3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
 - a. Report the cleanliness status of filters and the time static pressures are measured.
 4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
 5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 6. Obtain approval from Engineer and Commissioning Authority for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Division 23 Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 7. 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 will occur. 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 within specified tolerances.
1. Measure airflow of submain and branch ducts.
 - a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
 2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
 3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
- C. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
- D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
 2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
- B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
 2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure 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.
 3. Measure total system airflow. Adjust to within indicated airflow.
 4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
 5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
 6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
 8. Record final fan-performance data.
- C. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
 2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
 3. Set terminal units at full-airflow condition.
 4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
 5. Adjust terminal units for minimum airflow.
 6. Measure static pressure at the sensor.
 7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

3.8 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.
- B. Prepare schematic diagrams of systems' "as-built" piping layouts.
- C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
 1. Open all manual valves for maximum flow.
 2. Check liquid level in expansion tank.
 3. Check makeup water-station pressure gage for adequate pressure for highest vent.
 4. Check flow-control valves for specified sequence of operation, and set at indicated flow.
 5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
 6. Set system controls so automatic valves are wide open to heat exchangers.

7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.9 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.

3.10 PROCEDURES FOR STEAM SYSTEMS

- A. Measure and record upstream and downstream pressure of each piece of equipment.
- B. Measure and record upstream and downstream steam pressure of pressure-reducing valves.
- C. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.
- D. Check settings and operation of each safety valve. Record settings.
- E. Verify the operation of each steam trap.

3.11 PROCEDURES FOR HEAT EXCHANGERS

- A. Measure water flow through all circuits.
- B. Adjust water flow to within specified tolerances.
- C. Measure inlet and outlet water temperatures.
- D. Measure inlet steam pressure.
- E. Check settings and operation of safety and relief valves. Record settings.

3.12 PROCEDURES FOR MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
 1. Manufacturer's name, model number, and serial number.
 2. Motor horsepower rating.
 3. Motor rpm.
 4. Efficiency rating.
 5. Nameplate and measured voltage, each phase.
 6. Nameplate and measured amperage, each phase.
 7. Starter thermal-protection-element rating.

- B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.13 PROCEDURES FOR SPACE PRESSURIZATION MEASUREMENTS AND ADJUSTMENTS

- A. Before testing for space pressurization, observe the space to verify the integrity of the space boundaries. Verify that windows and doors are closed and applicable safing, gaskets, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.
- B. Measure, adjust, and record the pressurization of each room, each zone, and each building by adjusting the supply, return, and exhaust airflows to achieve the indicated conditions.
- C. Measure space pressure differential where pressure is used as the design criteria, and measure airflow differential where differential airflow is used as the design criteria for space pressurization.
 - 1. For pressure measurements, measure and record the pressure difference between the intended spaces at the door with all doors in the space closed. Record the high-pressure side, low-pressure side, and pressure difference between each adjacent space.
 - 2. For applications with cascading levels of space pressurization, begin in the most critical space and work to the least critical space.
 - 3. Test room pressurization first, then zones, and finish with building pressurization.
- D. To achieve indicated pressurization, set the supply airflow to the indicated conditions and adjust the exhaust and return airflow to achieve the indicated pressure or airflow difference.
- E. For spaces with pressurization being monitored and controlled automatically, observe and adjust the controls to achieve the desired set point.
 - 1. Compare the values of the measurements taken to the measured values of the control system instruments and report findings.
 - 2. Check the repeatability of the controls by successive tests designed to temporarily alter the ability to achieve space pressurization. Test overpressurization and underpressurization, and observe and report on the system's ability to revert to the set point.
 - 3. For spaces served by variable-air-volume supply and exhaust systems, measure space pressurization at indicated airflow and minimum airflow conditions.
- F. In spaces that employ multiple modes of operation, such as normal mode and emergency mode or occupied mode and unoccupied mode, measure, adjust, and record data for each operating mode.

- G. Record indicated conditions and corresponding initial and final measurements. Report deficiencies.

3.14 PROCEDURES FOR VIBRATION MEASUREMENTS

- A. Vibration testing for air handling unit motors will be performed by unit manufacturer.

3.15 TOLERANCES

- A. Set HVAC system's air flow rates and water flow rates within the following tolerances:
 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
 2. Air Outlets and Inlets: Plus or minus 10 percent
 3. Heating-Water Flow Rate: Plus or minus 10 percent
 4. Cooling-Water Flow Rate: Plus or minus 10 percent

3.16 REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- B. Status Reports: Prepare weekly 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.

3.17 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.
- 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 contractor.
 3. Project name.
 4. Project location.
 5. Architect's name and address.
 6. Engineer's name and address.
 7. Contractor's name and address.
 8. Report date.
 9. Signature of TAB supervisor who certifies the report.
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
 2. Water and steam flow rates.
 3. Duct, outlet, and inlet sizes.

4. Pipe and valve sizes and locations.
 5. Terminal units.
 6. Balancing stations.
 7. Position of balancing devices.
- E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches, and bore.
 - i. Center-to-center dimensions of sheave, and amount of adjustments in inches.
 - j. Number, make, and size of belts.
 - k. Number, type, and size of filters.
 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
 3. Test Data (Indicated and Actual Values):
 - a. Total air flow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Filter static-pressure differential in inches wg.
 - f. Preheat-coil static-pressure differential in inches wg.
 - g. Cooling-coil static-pressure differential in inches wg.

- h. Heating-coil static-pressure differential in inches wg.
 - i. Outdoor airflow in cfm.
 - j. Return airflow in cfm.
 - k. Outdoor-air damper position.
 - l. Return-air damper position.
 - m. Vortex damper position.
- F. Apparatus-Coil Test Reports:
- 1. Coil Data:
 - a. System identification.
 - b. Location.
 - c. Coil type.
 - d. Number of rows.
 - e. Fin spacing in fins per inch o.c.
 - f. Make and model number.
 - g. Face area in sq. ft.
 - h. Tube size in NPS.
 - i. Tube and fin materials.
 - j. Circuiting arrangement.
 - 2. Test Data (Indicated and Actual Values):
 - a. Air flow rate in cfm.
 - b. Average face velocity in fpm.
 - c. Air pressure drop in inches wg.
 - d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
 - e. Return-air, wet- and dry-bulb temperatures in deg F.
 - f. Entering-air, wet- and dry-bulb temperatures in deg F.
 - g. Leaving-air, wet- and dry-bulb temperatures in deg F.
 - h. Water flow rate in gpm.
 - i. Water pressure differential in feet of head or psig.
 - j. Entering-water temperature in deg F.
 - k. Leaving-water temperature in deg F.
 - l. Refrigerant expansion valve and refrigerant types.
 - m. Refrigerant suction pressure in psig.
 - n. Refrigerant suction temperature in deg F.

- o. Inlet steam pressure in psig.
- G. Fan Test Reports: For supply, return, and exhaust fans, include the following:
 1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches, and bore.
 - h. Center-to-center dimensions of sheave, and amount of adjustments in inches.
 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
 - g. Number, make, and size of belts.
 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Suction static pressure in inches wg.
- H. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
 1. Report Data:
 - a. System and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F.
 - d. Duct static pressure in inches wg.

- e. Duct size in inches.
 - f. Duct area in sq. ft.
 - g. Indicated air flow rate in cfm.
 - h. Indicated velocity in fpm.
 - i. Actual air flow rate in cfm.
 - j. Actual average velocity in fpm.
 - k. Barometric pressure in psig.
- I. Air-Terminal-Device Reports:
- 1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Apparatus used for test.
 - d. Area served.
 - e. Make.
 - f. Number from system diagram.
 - g. Type and model number.
 - h. Size.
 - i. Effective area in sq. ft.
 - 2. Test Data (Indicated and Actual Values):
 - a. Air flow rate in cfm.
 - b. Air velocity in fpm.
 - c. Preliminary air flow rate as needed in cfm.
 - d. Preliminary velocity as needed in fpm.
 - e. Final air flow rate in cfm.
 - f. Final velocity in fpm.
 - g. Space temperature in deg F.
- J. 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. Air flow rate in cfm.
 - b. Entering-water temperature in deg F.
 - c. Leaving-water temperature in deg F.
 - d. Water pressure drop in feet of head or psig.
 - e. Entering-air temperature in deg F.
 - f. Leaving-air temperature in deg F.

- K. 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.
 - g. Water pressure differential in feet of head or psig.
 - h. Required net positive suction head in feet of head or psig.
 - i. Pump rpm.
 - j. Impeller diameter in inches.
 - 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.
 - b. Pump shutoff pressure in feet of head or psig.
 - c. Actual impeller size in inches.
 - d. Full-open flow rate in gpm.
 - e. Full-open pressure in feet of head or psig.
 - f. Final discharge pressure in feet of head or psig.
 - g. Final suction pressure in feet of head or psig.

- h. Final total pressure in feet of head or psig.
 - i. Final water flow rate in gpm.
 - j. Voltage at each connection.
 - k. Amperage for each phase.
- L. Instrument Calibration Reports:
- 1. Report Data:
 - a. Instrument type and make.
 - b. Serial number.
 - c. Application.
 - d. Dates of use.
 - e. Dates of calibration.

3.18 INSPECTIONS

- A. Initial Inspection:
- 1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
 - 2. Check the following for each system:
 - a. Measure airflow of at least 10 percent of air outlets.
 - b. Measure water flow of at least 5 percent of terminals.
 - c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
 - d. Verify that balancing devices are marked with final balance position.
 - e. Note deviations from the Contract Documents in the final report.
- B. Final Inspection:
- 1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Commissioning Authority.
 - 2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Commissioning Authority.
 - 3. Commissioning Authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
 - 4. 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."

5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
- C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:
1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
 2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.
- D. Prepare test and inspection reports.

3.19 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 230593

SECTION 23 0713

DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes semi rigid and flexible duct, plenum, and breeching insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.
- B. Related Sections include the following:
 - 1. Division 7 Section "Penetration Firestopping" for firestopping materials and requirements for penetrations through fire and smoke barriers.
 - 2. Division 23 Section "HVAC Equipment Insulation" for insulation materials and application for pumps, tanks, hydronic specialties, and other equipment.
 - 3. Division 23 Section "HVAC Pipe Insulation" for insulation for piping systems.

1.3 SUBMITTALS

- A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.
- B. Installer Certificates: Signed by the Contractor certifying that installers comply with requirements.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.
- B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84 and NFPA 255 by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature. Deliver materials in original unopened packages, clearly marked with manufacturer's name, product designation, manufacturer's lot numbers, and appropriate UL Classification Label.
- B. Handle materials carefully and store in a sheltered area to avoid damage.

1.6 COORDINATION

- A. Coordinate clearance requirements with duct Installer for insulation application.

1.7 SCHEDULING

- A. Schedule insulation application after testing duct systems. Insulation application may begin on segments of ducts that have satisfactory test results.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Mineral-Fiber Insulation:
 - a. CertainTeed Manson.
 - b. Knauf FiberGlass GmbH.
 - c. Owens-Corning Fiberglas Corp.
 - d. Schuller International, Inc.

2.2 INSULATION MATERIALS

- A. Mineral-Fiber Board Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IB, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.
 - 1. Insulation shall have minimum nominal density of 6.0 lbs per cubic foot and a maximum thermal conductivity (K-factor) of 0.22 Btu-in/hr-ft²-°F at 75 degrees mean temperature based on ATSM C177.
- B. Mineral-Fiber Blanket Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.
 - 1. Insulation shall have minimum nominal density of 1.0 lb per cubic foot and a maximum thermal conductivity (K-factor) of 0.27 Btu-in/hr-ft²-°F at 75 degrees mean temperature based on ATSM C177.

2.3 FIELD-APPLIED JACKETS

- A. Aluminum Jacket: Deep corrugated sheets manufactured from aluminum alloy complying with ASTM B, and having an integrally bonded moisture barrier over entire surface in contact with insulation.
 - 1. Finish: Stucco-embossed finish.
 - a. Aluminum Thickness: 0.040 inch.
 - 2. Moisture Barrier: 1-mil-thick, heat-bonded polyethylene and kraft paper.

2.4 ACCESSORIES AND ATTACHMENTS

- A. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, presized a minimum of 8 oz./sq. yd..
 - 1. Tape Width: 4 inches.
- B. Bands: 3/4 inch wide, in one of the following materials compatible with jacket:
 - 1. Stainless Steel: ASTM A 666, Type 304; 0.020 inch thick.
 - 2. Galvanized Steel: 0.005 inch thick.
 - 3. Aluminum: 0.007 inch thick.
 - 4. Brass: 0.010 inch thick.
 - 5. Nickel-Copper Alloy: 0.005 inch thick.
- C. Wire: 0.080-inch, nickel-copper alloy; 0.062-inch, soft-annealed, stainless steel; or 0.062-inch, soft-annealed, galvanized steel.
- D. Weld-Attached Anchor Pins and Washers: Copper-coated steel pin for capacitor-discharge welding and galvanized speed washer. Pin length sufficient for insulation thickness indicated.
 - 1. Welded Pin Holding Capacity: 100 lb for direct pull perpendicular to the attached surface.

2.5 VAPOR RETARDERS

- A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
- 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 APPLICATION REQUIREMENTS

- A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of ducts and fittings.
- B. Refer to schedules at the end of this Section for materials, forms, jackets, and thickness required for each duct system.
- C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Apply multiple layers of insulation with longitudinal and end seams staggered.
- E. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.
- F. Keep insulation materials dry during application and finishing.
- G. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.
- H. Apply insulation with the least number of joints practical.
- I. Apply insulation over fittings and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
- J. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic. Apply insulation continuously through hangers and around anchor attachments.
- K. Insulation Terminations: For insulation application where vapor retarders are indicated, seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
- L. Apply insulation with integral jackets as follows:
 - 1. Pull jacket tight and smooth.
 - 2. Joints and Seams: Cover with tape and vapor retarder as recommended by insulation material manufacturer to maintain vapor seal.
 - 3. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- M. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.
- N. Install vapor-retarder mastic on ducts and plenums scheduled to receive vapor retarders.

1. Ducts with Vapor Retarders: Overlap insulation facing at seams and seal with vapor-retarder mastic and pressure-sensitive tape having same facing as insulation. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-retarder seal.
 2. Ducts without Vapor Retarders: Overlap insulation facing at seams and secure with outward clinching staples and pressure-sensitive tape having same facing as insulation.
- O. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.
1. Seal penetrations with vapor-retarder mastic.
 2. Apply insulation for exterior applications tightly joined to interior insulation ends.
 3. Seal insulation to roof flashing with vapor-retarder mastic.
- P. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.
- Q. Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire/smoke damper sleeves for fire-rated wall and partition penetrations.
- R. Floor Penetrations: Terminate insulation at underside of floor assembly and at floor support at top of floor.
1. For insulation indicated to have vapor retarders, taper termination and seal insulation ends with vapor-retarder mastic.

3.4 MINERAL-FIBER INSULATION APPLICATION

- A. Blanket Applications for Ducts and Plenums: Secure blanket insulation with adhesive and anchor pins and speed washers.
1. Apply adhesives according to manufacturer's recommended coverage rates per square foot, for 100 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install anchor pins and speed washers on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches. Space 16 inches o.c. each way, and 3 inches maximum from insulation joints. Apply additional pins and clips to hold insulation tightly against surface at cross bracing.
 - c. Do not over compress insulation during installation.
 4. Impale insulation over anchors and attach speed washers.

5. 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. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation segment with 1/2-inch staples, 1 inch o.c., and cover with pressure-sensitive tape having same facing as insulation.
 7. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. Secure with steel band at end joints and spaced a maximum of 18 inches o.c.
 8. Apply insulation on rectangular duct elbows and transitions with a full insulation segment for each surface. Apply 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 the insulation surface with 6-inch- wide strips of the same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with anchor pins spaced 6 inches o.c.
 10. Apply vapor-retarder mastic to open joints, breaks, and punctures for insulation indicated to receive vapor retarder.
- B. Board Applications for Ducts and Plenums: Secure board insulation with adhesive and anchor pins and speed washers.
1. Apply adhesives according to manufacturer's recommended coverage rates per square foot, for 100 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Space anchor pins as follows:
 - a. On duct sides with dimensions 18 inches and smaller, along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches. Space 16 inches o.c. each way, and 3 inches maximum from insulation joints. Apply additional pins and clips to hold insulation tightly against surface at cross bracing.
 - c. Do not over compress insulation during installation.
 4. 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. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation segment with 1/2-inch staples, 1 inch o.c., and cover with pressure-sensitive tape having same facing as insulation.

6. Apply insulation on rectangular duct elbows and transitions with a full insulation segment for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Apply 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 the insulation surface with 6-inch- wide strips of the same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with anchor pins spaced 6 inches o.c.
8. Apply vapor-retarder mastic to open joints, breaks, and punctures for insulation indicated to receive vapor retarder.

3.5 FIELD-APPLIED JACKET APPLICATION

- A. Apply glass-cloth jacket, where indicated, directly over bare insulation or insulation with factory-applied jackets.
 1. Apply jacket smooth and tight to surface with 2-inch overlap at seams and joints.
 2. Embed glass cloth between two 0.062-inch-thick coats of jacket manufacturer's recommended adhesive.
 3. Completely encapsulate insulation with jacket, leaving no exposed raw insulation.

3.6 DUCT SYSTEM APPLICATIONS

- A. Insulation materials and thicknesses are specified in the following schedule.
- B. Table 3.6a Duct Insulation Application Schedule:

Service	Location	Operating / Ambient Temp (°F)	Material	R-Value	Vapor Retarder	Field Applied Jacket
Supply air ducts, inside of building and in unconditioned spaces.	Shafts, Corridors, Above ceilings.	55 / 78	Mineral fiber blanket	3.3	yes	no
Supply air ducts, inside of building and in unconditioned spaces.	Mechanical Rooms.	55 / 95	Mineral fiber blanket	5.0	yes	no
Relief air ductwork within 3'-0" from opening in building envelope, concealed or exposed	All Locations	75 / 75	Mineral fiber blanket	3.3	yes	no
Relief hood plenums.	All Locations	-16 / 75	Mineral fiber blanket	3.3	yes	no
Outside air and exhaust air louver plenums, concealed or exposed.	All Locations	-16 / 75	Mineral fiber board	3.3	yes	no

- C. Note: Listed R-value represents installed condition assuming 25% compression, not out-of-package R-value.
- D. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:
 1. Supply air ducts, inside of building and in conditioned spaces, exposed to view.
 2. Factory-insulated flexible ducts.
 3. Factory-insulated plenums, casings, and terminal boxes.

4. Flexible connectors.
5. Vibration-control devices.
6. Testing agency labels and stamps.
7. Nameplates and data plates.
8. Access panels and doors in air-distribution systems.

END OF SECTION

SECTION 23 0716

HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes blanket, board, and block insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.
- B. Related Sections include the following:
 - 1. Division 23 Section "Duct Insulation" for insulation materials and application for ducts and plenums.
 - 2. Division 23 Section "HVAC Pipe Insulation" for insulation for piping systems.

1.3 SUBMITTALS

- A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.
- B. Shop Drawings: Show fabrication and installation details for the following:
 - 1. Field application for each equipment type.
 - 2. Removable insulation sections at access panels.
 - 3. Application of field-applied jackets.
- C. 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.
- D. Installer Certificates: Signed by the Contractor certifying that installers comply with requirements.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.
- B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials

and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.
2. Insulation Installed Outdoors: Flame-spread rating of 75 or less, and smoke-developed rating of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate clearance requirements with equipment Installer for insulation application.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Mineral-Fiber Insulation:
 - a. CertainTeed Manson.
 - b. Knauf FiberGlass GmbH.
 - c. Owens-Corning Fiberglas Corp.
 - d. Schuller International, Inc.

2.2 INSULATION MATERIALS

- A. Mineral-Fiber Board Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IB, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.
- B. Mineral-Fiber Blanket Thermal Insulation: Glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II, without facing and with all-service jacket manufactured from kraft paper, reinforcing scrim, aluminum foil, and vinyl film.

2.3 ACCESSORIES AND ATTACHMENTS

- A. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, presized a minimum of 8 oz./sq. yd..
 1. Tape Width: 4 inches.
- B. Bands: 3/4 inch wide, in one of the following materials compatible with jacket:
 1. Stainless Steel: ASTM A 666, Type 304; 0.020 inch thick.
 2. Galvanized Steel: 0.005 inch thick.

3. Aluminum: 0.007 inch thick.
 4. Brass: 0.010 inch thick.
 5. Nickel-Copper Alloy: 0.005 inch thick.
- C. Wire: 0.080-inch, nickel-copper alloy; 0.062-inch, soft-annealed, stainless steel; or 0.062-inch, soft-annealed, galvanized steel.
- D. Self-Adhesive Anchor Pins and Speed Washers: Galvanized steel plate, pin and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness indicated.

2.4 VAPOR RETARDERS

- A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
- 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 APPLICATION REQUIREMENTS

- A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of equipment.
- B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each equipment system.
- C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either the wet or dry state.
- D. Apply multiple layers of insulation with longitudinal and end seams staggered.
- E. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.
- F. Keep insulation materials dry during application and finishing.
- G. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

- H. Apply insulation with the least number of joints practical.
- I. Apply insulation over fittings and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
- J. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic. Apply insulation continuously through hangers and around anchor attachments.
- K. Insulation Terminations: For insulation application where vapor retarders are indicated, seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
- L. Apply insulation with integral jackets as follows:
 - 1. Pull jacket tight and smooth.
 - 2. Joints and Seams: Cover with tape and vapor retarder as recommended by insulation material manufacturer to maintain vapor seal.
 - 3. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to flanges and fittings.
- M. Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.
- N. Install vapor-retarder mastic on equipment scheduled to receive vapor retarders. Overlap insulation facing at seams and seal with vapor-retarder mastic and pressure-sensitive tape having same facing as insulation. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-retarder seal.
- O. Insulate the following indoor equipment:
 - 1. Heating hot-water and chilled water air separators (small tanks).
 - 2. Steam-to-water converters, not factory insulated.
 - 3. Chilled water pump bodies.
- P. Omit insulation from 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 FIELD QUALITY CONTROL

- A. Inspection: Perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:
 - 1. Inspect pumps and tanks randomly selected by Engineer.

2. Remove insulation and covers from two small tanks or one percent of small tanks, whichever is greater.
- B. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.
- C. Reinstall insulation and covers on pumps and tanks uncovered for inspection according to these Specifications.

3.5 EQUIPMENT APPLICATIONS

- A. Insulation materials and thickness are specified in schedules at the end of this Section.
- B. Materials and thickness for systems listed below are specified in schedules at the end of this Section.

3.6 INTERIOR TANK AND VESSEL INSULATION APPLICATION SCHEDULE

- A. Equipment: Heating hot-water air separators..
1. Operating Temperature: 100 to 200 deg F.
 2. Insulation Material: Mineral fiber, with jacket.
 3. Insulation Thickness: 1-1/2 inch
 4. Field-Applied Jacket: No.
 5. Vapor Retarder Required: No.
 6. Finish: None.
- B. Equipment: Steam-to-water converters.
1. Operating Temperature: 100 to 450 deg F.
 2. Insulation Material: Mineral fiber.
 3. Insulation Thickness: 3 inch
 4. Field-Applied Jacket: No.
 5. Vapor Retarder Required: No.
 6. Finish: None.

END OF SECTION 23 0716

SECTION 23 07 19

HVAC PIPE INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes preformed, rigid and flexible pipe insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds for new and existing piping.
- B. Related Sections include the following:
 - 1. Division 7 Section "Penetration Firestopping" for firestopping materials and requirements for penetrations through fire and smoke barriers.
 - 2. Division 23 Section "HVAC Duct Insulation" for insulation for ducts and plenums.
 - 3. Division 23 Section "HVAC Equipment Insulation" for insulation materials and application for pumps, tanks, hydronic specialties, and other equipment.
 - 4. Division 23 Section "HVAC Hangers and Supports" for pipe insulation shields and protection saddles.

1.3 SUBMITTALS

- A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.
- 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.
- C. Installer Certificates: Signed by the Contractor certifying that installers comply with requirements.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.
- B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency

acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.
2. Insulation Installed Outdoors: Flame-spread rating of 75 or less, and smoke-developed rating of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "HVAC Hangers and Supports."
- B. Coordinate clearance requirements with piping Installer for insulation application.

1.7 SCHEDULING

- A. Schedule insulation application after testing piping systems and, where required, after installing and testing heat-trace tape. Insulation application may begin on segments of piping that have satisfactory test results.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Mineral-Fiber/Mineral Wool Insulation:
 - a. CertainTeed Manson.
 - b. Knauf FiberGlass GmbH.
 - c. Owens-Corning Fiberglas Corp.
 - d. Schuller International, Inc.
 2. Cellular-Glass Insulation:
 - a. Pittsburgh-Corning Corp.
 3. Flexible Elastomeric Thermal Insulation:
 - a. Armstrong World Industries, Inc.
 - b. Rubatex Corp.
 4. Polyolefin Insulation:
 - a. Armstrong World Industries, Inc.

- b. IMCOA.
- 5. Calcium Silicate Insulation:
 - a. Owens-Corning Fiberglas Corp.
 - b. Pabco.
 - c. Schuller International, Inc.

2.2 INSULATION MATERIALS

- A. Mineral-Fiber Insulation: Glass fibers bonded with a thermosetting resin complying with the following:
 - 1. Preformed Pipe Insulation: Comply with ASTM C 547, Type 1, with factory-applied, all-purpose, vapor-retarder jacket.
 - 2. Blanket Insulation: Comply with ASTM C 553, Type II, without facing.
 - 3. Fire-Resistant Adhesive: Comply with MIL-A-3316C in the following classes and grades:
 - a. Class 1, Grade A for bonding glass cloth and tape to unfaced glass-fiber insulation, for sealing edges of glass-fiber insulation, and for bonding lagging cloth to unfaced glass-fiber insulation.
 - b. Class 2, Grade A for bonding glass-fiber insulation to metal surfaces.
 - 4. Vapor-Retarder Mastics: Fire- and water-resistant, vapor-retarder mastic for indoor applications. Comply with MIL-C-19565C, Type II.
 - 5. Mineral-Fiber Insulating Cements: Comply with ASTM C 195.
 - 6. Expanded or Exfoliated Vermiculite Insulating Cements: Comply with ASTM C 196.
 - 7. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/.
- B. Mineral-Fiber (Fiberglass) Insulation: Glass fibers bonded with a thermosetting resin complying with the following:
 - 1. Preformed Pipe Insulation: Comply with ASTM C 547, Type I, (850 °F), minimum density 3 lb/ft³, with factory-applied, 11 oz canvas jacket.
 - 2. Fire-Resistant Adhesive: Comply with MIL-A-3316C in the following classes and grades:
 - a. Class 1, Grade A for bonding glass cloth and tape to unfaced glass-fiber insulation, for sealing edges of glass-fiber insulation, and for bonding lagging cloth to unfaced glass-fiber insulation.
 - b. Class 2, Grade A for bonding glass-fiber insulation to metal surfaces.
 - 3. Vapor-Retarder Mastics: Fire- and water-resistant, vapor-retarder mastic for indoor applications. Comply with MIL-C-19565C, Type II.
 - 4. Mineral-Fiber Insulating Cements: Comply with ASTM C 195.

5. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.
- C. Cellular-Glass Insulation: Inorganic, foamed or cellulated glass, annealed, rigid, hermetically sealed cells, incombustible.
1. Preformed Pipe Insulation, without Jacket: Comply with ASTM C 552, Type II, Class 1.
 2. Preformed Pipe Insulation, with Jacket: Comply with ASTM C 552, Type II, Class 2.
- D. Flexible Elastomeric Thermal Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
1. Adhesive: As recommended by insulation material manufacturer.
 2. Ultraviolet-Protective Coating: As recommended by insulation manufacturer.
- E. Polyolefin Insulation: Unicellular polyethylene thermal plastic, preformed pipe insulation. Comply with ASTM C 534, Type I, except for density.
1. Adhesive: As recommended by insulation material manufacturer.
- F. Calcium Silicate Insulation: Preformed pipe sections of noncombustible, inorganic, hydrous calcium silicate with a nonasbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
- G. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

2.3 FIELD-APPLIED JACKETS

- A. General: ASTM C 921, Type 1, unless otherwise indicated.
- B. Foil and Paper Jacket: Laminated, glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil.
- C. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils thick; roll stock ready for shop or field cutting and forming.
1. Adhesive: As recommended by insulation material manufacturer.
 2. PVC Jacket Color: White or gray.

- D. Standard PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 20-mil- thick, high-impact, ultraviolet-resistant PVC.
 - 1. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.
 - 2. Adhesive: As recommended by insulation material manufacturer.
- E. Aluminum Jacket: Factory cut and rolled to sizes indicated. Comply with ASTM B 209, 3003 alloy, H-14 temper.
 - 1. Finish and Thickness: Corrugated finish, 0.010 inch thick.
 - 2. Moisture Barrier: 1-mil- thick, heat-bonded polyethylene and kraft paper.
 - 3. Elbows: Preformed, 45- and 90-degree, short- and long-radius elbows; same material, finish, and thickness as jacket.

2.4 ACCESSORIES AND ATTACHMENTS

- A. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, presized a minimum of 8 oz./sq. yd..
 - 1. Tape Width: 4 inches.
- B. Bands: 3/4 inch wide, in one of the following materials compatible with jacket:
 - 1. Stainless Steel: ASTM A 666, Type 304; 0.020 inch thick.
 - 2. Galvanized Steel: 0.005 inch thick.
 - 3. Aluminum: 0.007 inch thick.
 - 4. Brass: 0.010 inch thick.
 - 5. Nickel-Copper Alloy: 0.005 inch thick.
- C. Wire: 0.080-inch, nickel-copper alloy; 0.062-inch, soft-annealed, stainless steel; or 0.062-inch, soft-annealed, galvanized steel.

2.5 VAPOR RETARDERS

- A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry pipe and fitting surfaces. Remove materials that will adversely affect insulation application.

3.3 GENERAL APPLICATION REQUIREMENTS

- A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.
- B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each piping system.
- C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Apply insulation with longitudinal seams at top and bottom of horizontal pipe runs.
- E. Apply 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. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.
- H. Keep insulation materials dry during application and finishing.
- I. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.
- J. Apply insulation with the least number of joints practical.
- K. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated. Refer to special instructions for applying insulation over fittings, valves, and specialties.
- L. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic.
 - 1. Apply insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor retarders are indicated, extend insulation on anchor legs at least 12 inches from point of attachment to pipe and taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
 - 3. Install insert materials and apply insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.
- M. Insulation Terminations: For insulation application where vapor retarders are indicated, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.
- N. Apply adhesives and mastics at the manufacturer's recommended coverage rate.
- O. Apply insulation with integral jackets as follows:
1. Pull jacket tight and smooth.
 2. Circumferential Joints: Cover with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4 inches o.c.
 3. Longitudinal Seams: Overlap jacket seams at least 1-1/2 inches. Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
 - a. Exception: Do not staple longitudinal laps on insulation having a vapor retarder.
 4. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.
 5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor-retarder mastic.
- P. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.
1. Seal penetrations with vapor-retarder mastic.
 2. Apply insulation for exterior applications tightly joined to interior insulation ends.
 3. Extend metal jacket of exterior insulation outside roof flashing at least **2 inches** below top of roof flashing.
 4. Seal metal jacket to roof flashing with vapor-retarder mastic.
- Q. Exterior Wall Penetrations: For penetrations of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retarder mastic.
- R. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.
- S. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions.
1. Firestopping and fire-resistive joint sealers are specified in Division 7 Section "Firestopping."

- T. Floor Penetrations: Apply insulation continuously through floor assembly.
 - 1. For insulation with vapor retarders, seal insulation with vapor-retarder mastic where floor supports penetrate vapor retarder.

3.4 MINERAL-FIBER INSULATION APPLICATION

- A. Apply insulation to straight pipes and tubes as follows:
 - 1. Secure each layer of preformed pipe insulation to pipe with wire, tape, or bands without deforming insulation materials.
 - 2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic. Apply vapor retarder to ends of insulation at intervals of 15 to 20 feet to form a vapor retarder between pipe insulation segments.
 - 3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches o.c.
 - 4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.
- B. Apply insulation to flanges as follows:
 - 1. Apply preformed pipe insulation to outer diameter of pipe flange.
 - 2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
 - 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
 - 4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch, and seal joints with vapor-retarder mastic.
- C. Apply insulation to fittings and elbows as follows:
 - 1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
 - 2. When premolded insulation elbows and fittings are not available, apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire, tape, or bands.
 - 3. Cover fittings with heavy PVC fitting covers. Overlap PVC covers on pipe insulation jackets at least 1 inch at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
- D. Apply insulation to valves and specialties as follows:
 - 1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When premolded insulation sections are not available, apply glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to stainer basket without disturbing insulation.
3. Apply insulation to flanges as specified for flange insulation application.
4. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
5. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.5 CELLULAR-GLASS INSULATION APPLICATION

- A. Apply insulation to straight pipes and tubes as follows:
 1. Secure each layer of insulation to pipe with wire, tape, or bands without deforming insulation materials.
 2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic.
 3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches o.c.
 4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.
- B. Apply insulation to flanges as follows:
 1. Apply preformed pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of the same thickness as pipe insulation.
 4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch, and seal joints with vapor-retarder mastic.
- C. Apply insulation to fittings and elbows as follows:
 1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
 2. When premolded sections of insulation are not available, apply mitered sections of cellular-glass insulation. Secure insulation materials with wire, tape, or bands.
 3. Cover fittings with heavy PVC fitting covers. Overlap PVC covers on pipe insulation jackets at least 1 inch at each end. Secure fitting covers with

manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

- D. Apply insulation to valves and specialties as follows:
1. Apply premolded segments of cellular-glass insulation or glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to stainer basket without disturbing insulation.
 2. Apply insulation to flanges as specified for flange insulation application.
 3. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
 4. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.6 FLEXIBLE ELASTOMERIC THERMAL INSULATION APPLICATION

- A. Apply insulation to straight pipes and tubes as follows:
1. Follow manufacturer's written instructions for applying insulation.
 2. Seal longitudinal seams and end joints with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.
- B. Apply insulation to flanges as follows:
1. Apply pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the 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 the same thickness as pipe insulation.
 4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.
- C. Apply insulation to fittings and elbows as follows:
1. Apply mitered sections of pipe insulation.
 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.
- D. Apply insulation to valves and specialties as follows:
1. Apply preformed valve covers manufactured of the same material as pipe insulation and attached according to the manufacturer's written instructions.

2. Apply cut segments of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, fabricate removable sections of insulation arranged to allow access to stainer basket.
3. Apply insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

3.7 CALCIUM SILICATE INSULATION APPLICATION

- A. Apply insulation to straight pipes and tubes as follows:
1. Secure each layer of insulation to pipe with stainless-steel bands at 12-inch intervals and tighten without deforming insulation materials.
 2. Apply two-layer insulation with joints tightly butted and staggered at least 3 inches. Secure inner layer with 0.062-inch, soft-annealed, stainless-steel wire spaced at 12-inch intervals. Secure outer layer with stainless-steel bands at 12-inch intervals.
 3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to surface of installed insulation. When dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch. Apply finish coat of lagging adhesive over glass cloth or tape. Thin the finish coat to achieve smooth finish.
- B. Apply insulation to flanges as follows:
1. Apply preformed pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of the same material and thickness as pipe insulation.
 4. Finish flange insulation the same as pipe insulation.
- C. Apply insulation to fittings and elbows as follows:
1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
 2. When premolded sections of insulation are not available, apply mitered sections of calcium silicate insulation. Secure insulation materials with stainless-steel wire.
 3. Finish insulation of fittings the same as pipe insulation.
- D. Apply insulation to valves and specialties as follows:
1. Apply mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without

disturbing insulation. For check valves, arrange insulation for access to stainer basket without disturbing insulation.

2. Apply insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation the same as pipe insulation.

3.8 FIELD-APPLIED JACKET APPLICATION

- A. Apply glass-cloth jacket, where indicated, directly over bare insulation or insulation with factory-applied jackets.
 1. Apply jacket smooth and tight to surface with 2-inch overlap at seams and joints.
 2. Embed glass cloth between two 0.062-inch-thick coats of jacket manufacturer's recommended adhesive.
 3. Completely encapsulate insulation with jacket, leaving no exposed raw insulation.
- B. Foil and Paper Jackets: Apply foil and paper jackets where indicated.
 1. Draw jacket material smooth and tight.
 2. Apply lap or joint strips with the same material as jacket.
 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 4. Apply jackets with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-retarder mastic.
- C. Apply PVC jacket where indicated, with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.
 1. Piping NPS 2-1/2 and smaller: 20-mil.
 2. Piping NPS 3 and Larger: 30-mil.
- D. Apply metal jacket where indicated, with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.9 FINISHES

- A. Glass-Cloth Jacketed Insulation: Paint insulation finished with glass-cloth jacket as specified in Division 9 Section "Painting."
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of the 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.

3.10 PIPING SYSTEM APPLICATIONS

- A. Insulation materials and thicknesses are specified in schedules at the end of this Section.
- B. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:
 - 1. Flexible connectors.
 - 2. Vibration-control devices.
 - 3. Fire-suppression piping.
 - 4. Drainage piping located in crawl spaces, unless otherwise indicated.
 - 5. Below-grade piping, unless otherwise indicated.
 - 6. Chrome-plated pipes and fittings, unless potential for personnel injury.
 - 7. Air chambers, unions, strainers, check valves, plug valves, and flow regulators.

3.11 FIELD QUALITY CONTROL

- A. Inspection: Perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:
 - 1. Inspect fittings and valves randomly selected by Engineer.
- B. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.
- C. Reinstall insulation and covers on fittings and valves uncovered for inspection according to these Specifications.

3.12 INSULATION APPLICATION SCHEDULE, GENERAL

- A. Refer to insulation application schedules for required insulation materials, vapor retarders, and field-applied jackets.
- B. Application schedules identify piping system and indicate pipe size ranges and material, thickness, and jacket requirements.

3.13 INTERIOR INSULATION APPLICATION SCHEDULE

- A. Table 3.13a

Service	Operating / Ambient Temp (°F)	Material	Thickness (in)	Layers	Vapor Retarder Required	Field Applied Jacket
Condensate drain piping	35 to 75	Mineral fiber	1	1	Yes	None
Chilled-water supply and return: Inside of Building Steel and Copper Pipe, 1" and smaller	40 to 75	Mineral fiber	½	1	Yes	None
Chilled-water supply and return: Inside of Building Steel and Copper Pipe, 1¼" to 2"	40 to 75	Mineral fiber	¾	1	Yes	None
Chilled-water supply and return:	40 to 75	Mineral fiber	1	1	Yes	None

Service	Operating / Ambient Temp (°F)	Material	Thickness (in)	Layers	Vapor Retarder Required	Field Applied Jacket
Inside of Building Steel and Copper Pipe, 2½" and larger						
Heating hot-water supply and return: Steel and Copper Pipe, 2" and smaller	100 to 200	Mineral fiber	1	1	No	None
Heating hot-water supply and return: Steel and Copper Pipe, 2½" and larger	100 to 200	Mineral fiber	1½	1	No	None
Low Pressure Steam, Low Pressure Condensate, and Pumped Condensate Steel Pipe 2" and smaller	0 to 250	Mineral fiber	1½	1	No	PVC
Low Pressure Steam, Low Pressure Condensate, and Pumped Condensate Steel Pipe 2" to 6"	0 to 250	Mineral fiber	2	1	No	PVC

END OF SECTION

SECTION 23 0900

HVAC INSTRUMENTATION AND CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.
- B. Sequences of operation and system schematics are included on the drawings. This section is to be referenced in conjunction with the sequences shown on the drawings.

1.2 GENERAL

- A. Provide all labor, materials, equipment, installation, service and training necessary for a complete, operational, and fully commissioned direct digital control (DDC) system for the facilities identified on the contract drawings. The system shall use the BACnet protocol at the TCP/IP level of the architecture.
- B. Provide all labor, materials, equipment, service, and training necessary to integrate the new DDC systems into the existing University DDC network. The communications protocol used by the University is BACnet/IP.
- C. Control systems shall be installed by experienced personnel regularly engaged in such installations and in the full employ of the manufacturer or in the employ of a franchised licensee of the manufacturer.
- D. The controls contractor shall include minor items, which are obviously and reasonably necessary to complete the installation and usually included in similar work even though not specifically mentioned in the Contract Documents.
- E. Temperature control panels and/or enclosures in equipment rooms shall be located at readily accessible walkup locations approved by the University's Owner Representative.
- F. Building Systems Automation Center (BSAC)
 - 1. The University owns and operates BSAC, which provides central monitoring of HVAC systems, fire and life safety systems, and other building systems on the Twin Cities campus. Each addition and/or alteration to a building control system shall be designed to work with the BSAC systems. BSAC uses the MultiLiant workstation (MLWS) as the primary DDC alarm monitoring device.
 - 2. BSAC is presently located in the Donhowe Building on the East Bank Campus.
- G. University DDC Network
 - 1. The University owns and operates a dedicated mixed-mode network (fiber and copper) for building-to-building and building-to-BSAC communications. Energy Management is responsible for network design and network device maintenance. The DDC network is a private LAN with no Internet connections.

2. The University DDC system uses Distributed Process Architecture to monitor, control and integrate pneumatic, electric, and DDC systems. The controls contractor shall consider the DDC network an existing University utility system to which the specific building control system will be connected.
3. All building level devices must communicate using BACnet/IP and must support the objects and services listed in this specification. The University of Minnesota is committed to integration so that point status and automatic control can be channeled into a common protocol. The University has established BACnet as the common protocol.

H. University DDC System Functions

1. The general categories of the automated capabilities of the University DDC system are:
 - a. Monitoring and Scheduling: Includes starting, stopping, observing, and reporting the operating status of the equipment, systems, and subsystems.
 - b. Intervention: The ability to automatically or manually shift to an alternate operating mode when weather or other conditions warrant it from a remote location.
 - c. Integration: The ability to coordinate the operation of several systems within a building, or several subsystems within a system, to ensure most efficient operation.
 - d. Management Information: The ability to provide cumulative operating data such as system run time, units of energy consumed, and preventive maintenance schedules.
2. All vendor DDC systems must be capable of functioning in the following modes:
 - a. All life safety and building systems points can be monitored and commanded, including equipment scheduling, by the MLWS and the vendor workstation 24 Hrs/Day, 7 Days/Wk.
 - b. System alarms shall be displayed and acknowledged at the vendor's workstation, and MLWS 24 Hrs/Day, 7 Days/Wk.
3. University personnel can make control set point, alarm limit and time schedule program modifications from the vendor's workstation or through any third party BACnet workstation.

I. BACnet Integration:

1. Due to the complexity and size of the University BACnet system, integration requires stringent cooperation between the Energy Management department and the selected temperature Controls contractor. The University requires direct communication with the manufacturer's highest level of customer support, and may need to converse with the manufacturer's BACnet development team during project design, implementation, commissioning, and warranty phases.
2. The University of Minnesota is committed to integrating different manufacturer's temperature control systems on a common LAN using a master workstation for all existing and future temperature control systems that may be installed. U of M BACnet required conformance is limited to B-Side or BACnet

building controllers, only. The temperature Controls contractor must provide labor, software, materials, wiring, fiber coordination and expertise to install BACnet Building Controller.

3. Bidding Controls contractor must indicate Readable, Writable or Not Supported under *Proposed Temperature Control Panel Conformance* column in Appendix A for all standard objects shown and return this information with their proposal.
4. BACnet communication shall be via the private DDC LAN directly from the building level controllers without having to route or convert it from a proprietary source. When building level network controllers are used for core BACnet communications, the field level panels on its sub LAN, such as VAVs and unitary level controllers, can utilize BACnet MS/TP, or LON. Building level network controllers shall be required to support the requirements of Appendix A.
5. BACnet conformance disputes that may arise in the temperature control contractors installed BACnet Building Controller will be resolved by U of M engineers working directly with the temperature Controls contractor's factory. Cost of translation between non-English speaking testers, developers and customer support personal whether overseas or in the USA will be the responsibility of the controls contractor. On site device testing will be conducted using the BACnet Manufacturers Association / BACnet Testing Laboratories (BMA/BTL) Virtual Test Shell 3.5.0 (VTS) program. Virtual Test Shell (VTS) is an application for testing the BACnet functionality of various devices used in building automation systems. It is available at <http://sourceforge.net/projects/vts/>. Conformance issue fault will be agreed on and resolved using ANSI/ASHRAE Standards 135-2004 publication.

1.3 RELATED SECTIONS

- A. None.

1.4 RELATED DOCUMENTS

- A. University of Minnesota Construction Standards. Note that this document supersedes section 15950 of the 2002 Construction Standards.

1.5 DEFINITION OF TERMS/ACRONYMS/ABBREVIATIONS

- A. Additional definitions of terms or acronyms are included on the contract drawings and in other sections of this specification.
- B. In the preparation of submittals and reports, the contractor shall use these definitions and abbreviations. Any terms or abbreviations used by the contractor in submittals and reports that have not been defined in this section shall be defined by the contractor in the first section of the submittal or report prior to their use.
- C. The following definitions serve as a guide for industry acronyms in the coming sections:
 1. ANSI - American National Standards Institute
 2. ASHRAE - American Society of Heating Refrigeration and Air Conditioning Engineers
 3. BACnet - Building Automation and Controls Network
 4. BAC/IP – BACnet communications protocol via IP

5. BACnet/MSTP – BACnet communications using master/slave token passing on a field bus.
6. BIBBs - BACnet Interoperability Building Blocks
7. BMA – BACnet Manufacturers Association
8. BTL – BACnet Testing Laboratories
9. CSV – Comma Separated Value
10. DDC - Direct Digital Controls
11. EIA - Electronic Industries Association
12. Field Bus – Communications link between unit level controllers (RS485 or LON)
13. IP – Internet Protocol
14. ISO - International Standards Organization
15. LAN - Local Area Network
16. LON – LONTalk communications protocol
17. LONTalk - Open, published protocol
18. LONWorks - A set of tools and components
19. NIST - National Institute of Standards and Technology
20. PIC - Protocol Implementation Conformance Statement
21. Point Expansion Modules – Devices that are connected to unit controllers via dedicated communication links that are intended to increase the physical point count for the unit controller.
22. VAV - Variable Air Volume

1.6 REFERENCES

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.
 1. AIR MOVEMENT AND CONTROL ASSOCIATION (AMCA)
 2. AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
 3. AMERICAN SOCIETY OF HEATING, REFRIGERATION AND AIR-CONDITIONING ENGINEERS (ASHRAE)
 - a. ASHRAE 135-2004 BACnet Standard
 4. FEDERAL COMMUNICATIONS COMMISSION (FCC)
 5. INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)
 6. INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)
 7. NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)
 8. NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
 9. UNDERWRITERS' LABORATORIES (UL)
 - a. UL 864

1.7 PRODUCTS FURNISHED, BUT NOT INSTALLED UNDER THIS SECTION

- A. Water-side pressure sensors. U of M will install required pressure sensors in existing piping. Controls contractor is responsible for all wiring, checkout, and commissioning of water-side pressure devices.

1.8 PRODUCTS INSTALLED, BUT NOT FURNISHED UNDER THIS SECTION

- A. None

1.9 PRODUCTS INTEGRATED WITH THE WORK OF THIS SECTION

- A. None

1.10 PROJECT DESCRIPTION

- A. The work covered by this specification and related sections consists of providing all plans, equipment, labor, materials, detailed control drawings of each piece of equipment, engineering, technicians and supervision as required to replace the existing Honeywell DDC controls (XL Plus) in building 165 (EECS). See the as-built control system drawings for details. A dedicated fiber communication trunk or dedicated copper cable will be used for network communication between the new network controllers and the existing campus DDC network. The work consists of, but is not limited to, the following:
 1. Replace the existing DDC controls.
 2. Furnish and install communications equipment necessary for the new control system to effectively transmit and receive data between building 165 and the existing campus DDC network.
 3. Outside air temperature shall be mapped globally to each controller. Provide a single outside air sensor for use by the building controllers. All global points must have an internal default value in every panel in case communication is disrupted to the main controller.
 4. Furnish and install all necessary hardware to monitor and control identified points as shown in the project drawings and points list(s).
 5. Furnish and install new enclosures for all new DDC panels, network equipment, and interfaces systems unless the Owner grants permission to reuse the existing DDC enclosures.
 6. Furnish and install A/C current sensors for monitoring status of constant speed fans and pumps. Status of motors controlled by VFDs shall be sensed by flow or pressure switches or as a binary input from the drive. Where common status sensors (flow or pressure) are present on alternating pump systems (i.e. lead/lag), remove and install A/C current sensors to monitor the lead and all lag pumps.
 7. The controls contractor is not responsible for installing new wells and well sensors shown in the system drawings or point lists.
 8. The controls contractor shall furnish but not install new pressure transducers required for all Steam, Hot Water, Chilled Water, and other non-airside system pressures. The specifications for the transducers are: Output Signal: 0.1 – 10Vdc/4-20mA (3-Wire) or 4-20mA (2-Wire); Supply Voltage - 10-36Vdc unregulated. The controls contractor shall furnish and install all required air-side pressure transducers.

9. Locate enclosures/controllers only at locations pre-approved by the University's Owner's Representative.
10. Reuse existing cable and conduit when possible. Where applicable install new conduit and cable. Follow all electrical code requirements.
11. Remove and properly dispose of all existing duct well, and pressure differential sensors, flow switches, wiring, enclosures, relays, miscellaneous parts, etc.
12. Return all existing Honeywell DDC controllers to the Owner.
13. Furnish, install and program all software necessary to implement a complete and operational system, including entry and verification of all data files, point mapping, graphics and trees.
14. Provide submittal documents, shop drawings, detailed equipment drawings for each piece of equipment with sequence of operations and specifications, construction documents, complete operating and maintenance manuals.
15. Accomplish commissioning and acceptance tests as indicated and provide a commissioning document of all systems.
16. Provide field service and warranty work as specified.
17. All NFPA references are per 2002 Edition.
18. Controls contractor is responsible for field verification of all equipment locations before the start of construction. All sensing elements (except for pipe wells, well sensors, hydronic pressure transducers) shall be installed, calibrated, and tested by the controls contractor.
19. All network connections and upgrades shall be performed in an acceptable manner to the University's Owner's Representative. Prior to connecting to the campus network the controls contractor shall contact the University's Owner's Representative.

1.11 SUBMITTALS

- A. Upon receipt of order, the controls contractor will submit drawings for approval prior to ordering or installing any equipment.
- B. Copies of all required software shall be submitted to the Owner prior to the start of construction. No pay applications will be approved until all required software has been received.
- C. A work schedule (implementation plan) shall be presented to the Owner before the start of work.
 1. All work shall be scheduled with the Owner to minimize building interruptions.
 2. Any service interruptions for making connections to the existing system shall be scheduled well in advance with the Owner and only during periods approved by the Owner.
 3. The schedule shall include a timeline for hardware changes, software programming, communication connections, training, projected completion dates, etc.
- D. If a conflict, error, omission or lack of detailed description is discovered in the Contract Documents, the controls contractor shall immediately notify the Owner and request

clarification. The Owner will resolve the conflict and make any corrections or interpretations necessary to fulfill the intent of the plans and specifications.

- E. Shop drawings shall be 11 inch by 17 inch, landscape, bound on the left edge. They shall be produced with Microsoft Visio or Autodesk AutoCAD software. Organize the packages by building. All documents shall be submitted electronically in portable document format (PDF). At the request of the Owner, shop drawings will also be submitted in the native CAD format.
- F. All text based documents and product data sheets shall be 8 ½ inch by 11 inch format bound on the left edge. All documents shall be submitted electronically in portable document format (PDF).
- G. Software files shall be submitted on fully labeled CDs that shall include a table of contents file in PDF format that provides a description of all of the files on the CD.
- H. Submittals Prior To Construction
 - 1. Shop Drawings
 - a. System Architecture Design Diagram
 - (1) A riser diagram that shall show the IP layer and all of the field bus layers.
 - (2) It shall show each computer, printer, router, repeater, controller, and protocol translator that is connected to either the IP layer or any of the field busses.
 - (3) Where applicable, this diagram shall include the existing control system that is to be integrated into the new system.
 - (4) Each component that is shown shall have a name that is representative of how it will be identified in the completed database and the manufacturer's name and model number.
 - (5) The physical relationship of one component to another component shall reflect the proposed installation.
 - (6) This diagram shall not include power supplies, sensors or end devices.
 - b. Layout Design Drawing for each control panel:
 - (1) The layout drawing shall be to scale with all devices shown in their proposed positions.
 - (2) All control devices shall be identified by name.
 - (3) All terminal strips and wire channels shall be shown.
 - (4) All control transformers shall be shown.
 - (5) All 120 VAC receptacles shall be shown.
 - (6) All IP connection points shall be shown.
 - c. Wiring Design Diagram for each control panel.
 - (1) The control voltage wiring diagram shall clearly designate devices powered by each control transformer. The diagram shall clearly show the consistent grounding of the appropriate power connection. All wire identification numbers shall be annotated on the diagram.
 - (2) The Field Bus wiring diagram shall clearly show the use of the daisy chain wiring concept, the order in which the devices are connected to the Field Bus, and the location of end of segment

- termination devices. All wire identification numbers shall be annotated on the diagram.
- (3) If shielded communication wiring is used, the grounding of the shield shall be shown.
 - (4) The terminal strip wiring diagram shall identify all connections on both sides of the terminal strip. Wiring label numbers for all wiring leaving the control panel shall be annotated on the diagram.
 - (5) Where pneumatic devices are monitored or controlled by the DDC systems, the control panel wiring diagrams shall include pneumatic piping diagrams for all components.
- d. Wiring Design Diagram for individual components (controllers, protocol translators, etc.): The wiring diagram for each component shall identify all I/O, power, and communication wiring and the locations on the terminal blocks to which the wires are landed.
 - e. Installation Design Detail for each I/O device.
 - (1) A drawing of the wiring details for each sensor and/or end device.
 - (2) For devices with multiple quantities, a standard detail may be submitted.
 - f. A System Flow Design Diagram for each controlled system.
 - (1) A two dimensional cross sectional diagram showing key components such as fans, coils, dampers, valves, pump, etc.
 - (2) Identify the locations and names of all sensors and end devices that are associated with the control system. Label the panel name and terminal numbers where the connections are landed.
 - (3) A legend shall be provided for all symbols used.
2. Data
- a. BACnet Compliance Documentation:
 - (1) BACnet Interoperability Building Blocks (BIBBs) and PICS Statement: The Contractor will submit up-to-date PICS and BIBBs Statements for each controller and workstation showing ANSI/ASHRA 135-2004 BACnet communication protocol standards that identifies all of the portions of BACnet that the vendor adheres to. The PIC statement must show conformance to the BACnet devices the vendor proposes to use. See Appendix A for additional PIC information. The vendor PICS statement will contain the following:
 - (a) BACnet protocol revision
 - (b) Applications software and firmware revision
 - (c) Vendor and BACnet object description
 - (d) BIBBs supported by the device
 - (e) The standardized BACnet device profile to which the device conforms
 - (f) The non-standardized BACnet device application services
 - (g) A list of all standard and proprietary object types that are supported

- (h) For each object type that is supported, the University requires the following:
 - (1) Optional properties that are supported with the device or BACnet server
 - (2) A list of properties that can be written using BACnet services
 - (3) Any object that can be dynamically created or deleted using BACnet services
 - (4) Any restrictions in the data value range for properties
 - (i) Data link layer options supported
 - (j) Device address binding (necessary for two-way communication with MS/TP devices)
 - (k) Networking options (BBMD, MS/TP)
 - (l) Character sets supported
 - (m) Segmented requests or responses supported
- b. Direct Digital Control System Hardware Technical Data.
 - (1) A complete bill of materials of equipment to be used indicating quantity, manufacturer, and model number.
 - (2) Manufacturer's description and technical data for each unique device to include performance curves, product specification sheets, and installation instructions. When a manufacturer's data sheet refers to a series of devices rather than a specific model, the data specifically applicable to the project shall be highlighted or clearly indicated by other means.
 - (3) This requirement applies to:
 - (a) Controllers
 - (b) Transducers/Transmitters
 - (c) Sensors
 - (d) Actuators
 - (e) Valves
 - (f) Relays and Switches
 - (g) Control Panels
 - (h) Power Supplies
 - (i) Batteries
 - (j) Operator Interface Equipment
- c. An Instrumentation List for each controlled system.
 - (1) The list shall be in a table format.
 - (2) Include name, type of device, manufacturer, model number, and product data sheet number.
- d. Sequence of Control: A sequence of control for each system being controlled. Include the following as a minimum.
 - (1) Process control sequence for each end device.
 - (2) Supervisory logic sequence of control for each system.
 - (3) The impact of each global application program on the sequence of control (Example: Demand Control).
 - (4) A list of all physical inputs and outputs associated with each sequence.
 - (5) Within the sequence of control, all application parameters that are to be user adjustable from an OWS shall be annotated with (adj) after the name of the parameter. This shall include set points, reset schedule parameters, calibration offsets, timer settings, control loop parameters such as gain, integral time constant, sample rates, differentials, etc.

- (6) All points that shall be subject to manual control from an operator workstation.
 - (7) A list of all alarm points, a description of the alarm and a description of the alarm criteria.
 - e. Binding Map
 - (1) A list of the device-to-device (peer-to-peer) data flow. This shall not include the flow of data from devices to the OWS.
 - (2) Include:
 - (a) Description of the variable.
 - (b) Sending device.
 - (c) Receiving device.
- I. Submittals During Construction
- 1. Training Manuals for each Training Course
 - a. Submit the following six weeks in advance of the training:
 - (1) List of training objectives.
 - (2) Outline of the course with time allocations per topic.
 - (3) Training presentation material (slides, word documents, etc.).
 - (4) Copy of training reference material (product manuals to be used, etc.).
 - (5) Schematic of the training equipment to be used with model numbers on each component.
 - (6) A description of the measurement devices to measure training effectiveness (quizzes, programming exercises, course exam).
 - (7) Instructor's name and resume with an emphasis on experience in presenting training programs.
 - 2. Startup Testing Plan: Submit a start up testing plan for each unique system.
 - a. The purpose of a startup test is to demonstrate the completeness of the physical tasks associated with installation and the performance of the components.
 - b. For each task on the startup test checklist, the plan shall require the technician to enter his or her initials and the date the test was completed along with any recorded data such as voltages, offsets, or tuning parameters. Any deviations from the submitted installation plan shall also be recorded.
 - c. Required elements of the startup testing include:
 - (1) Measurement of voltage sources, primary and secondary.
 - (2) Verification of proper controller power wiring.
 - (3) Verification of component inventory when compared to the submittals.
 - (4) Verification of labeling on components and wiring.
 - (5) Verification of connection integrity and quality (loose strands and tight connections).
 - (6) Verification of bus topology, grounding of shields and installation of termination devices.
 - (7) Verification of point checkout.
 - (a) Each I/O device is landed per the submittals and functions per the sequence of control.

- (b) Analog sensors are properly scaled and a value is reported.
- (c) Binary sensors have the correct normal position and the state is correctly reported.
- (d) Analog outputs have the correct normal position and move full stroke when so commanded.
- (5) Analog outputs shall be tested to verify that any controlled pneumatic devices travel full stroke when the AO is varied from 0% to 100% output.
 - (e) Binary outputs have the correct normal state and respond appropriately to energize/de-energize commands.
- (8) Documentation of analog sensor calibration (measured value, reported value and calculated offset).
- (9) Documentation of Loop tuning (sample rate, gain and integral time constant).
- d. Submit at least two weeks prior to equipment startup.
- 3. Startup Testing Report.
 - a. Startup testing reports shall be submitted on a per system basis.
 - b. Startup testing reports shall be the documented results of the executed startup testing plans.
- 4. Graphic Pages: Submit a sample graphic page for each type of page described in the specification section on graphic pages.

J. Submittals After Construction

- 1. The following is a list of post construction submittals that shall be updated to reflect any changes during construction and re-submitted as "As-Built". As-Built drawings will each be stamped "As-Built" and have the as-built date on them. The As-Built drawings will contain at a minimum:
 - a. System architecture drawing.
 - b. Detailed drawings for each piece of controlled and monitored equipment
 - (1) Layout drawing for each control panel.
 - (2) Wiring diagram for each control panel.
 - (3) Wiring diagram for individual components.
 - (4) Point lists
 - (5) Room Schedules
 - (6) Sequence of operation
 - (7) Hardware with part number information
 - (8) System flow diagram for each controlled system.
 - c. Detailed routing of all communication trunk wires (building-to-building and within building), locations of all network and integration devices, front-end workstations, UPS and campus network/LAN connections.
 - d. Binding map.
- 2. Operation and Maintenance Manuals
 - a. The controls contractor shall provide one electronic (PDF) copy and three (3) bound copies of Operation and Maintenance Manuals.
 - b. Deliver manuals to the University project manager.

- c. Manuals shall be bound in heavy-duty, vinyl-covered, three-post, loose-leaf binders, permanently labeled on front and spine of each binder.
- d. Arrange the manuals according to specification section numbers used in the Project Manual; include a table of contents that identifies the responsible installing contractor, contact person, and telephone number with area code and thumb tab index sheets.
- e. Provide pocket folders for folded sheet information.
- f. Maintenance and Operating Manual shall include the following type of information:
 - (1) One copy of the executed Certificate(s) of Substantial Completion. This document will be used to communicate to all necessary University personnel the starting date of the one-year Warranty period.
 - (2) Signed record copy of bonds, guarantees, and warranties required by the Contract Documents.
 - (3) Manufacturer's required preventative maintenance inspections, testing, service, lubrication, maintenance instructions, and schedules.
 - (4) Parts lists and local service organization.
 - (5) As-built wiring and piping diagrams.
 - (6) System architecture diagram for components within the building annotated with specific location information.
 - (7) As-built drawing for each control panel.
 - (8) As-built wiring design diagram for each control panel.
 - (9) As-built wiring design diagram for all components.
 - (10) Installation design details for each I/O device.
 - (11) As-built system flow diagram for each system.
 - (12) Sequence of control for each system.
 - (13) Room schedules.
 - (14) Binding map for the building.
 - (15) Product data sheet for each component.
 - (16) Installation data sheet for each component.
 - (17) Other information required by the Specifications.
- g. The Contractor shall instruct University personnel in the use of Maintenance and Operating Manuals.

3. Software

- a. Submit a copy of all software installed on the servers and workstations.
- b. Submit all licensing information for all software installed on the servers and workstations.
- c. Submit a copy of all software used to execute the project even if the software was not installed on the servers and workstations.
- d. Submit all licensing information for all of the software used to execute the project.
- e. All software revisions shall be as installed at the time of the system acceptance.

4. Firmware Files

- a. Submit a copy of all firmware files that were downloaded to or pre-installed on any devices installed as part of this project.
 - b. This does not apply to firmware that is permanently burned on a chip at the factory and can only be replaced by replacing the chip.
 - c. Submit a copy of all application files that were created during the execution of the project.
 - d. Submit a copy of all graphic page files created during the execution of the project.
 - e. Submit a copy of all secondary graphic files such as bitmaps, jpegs, etc. that were used in the creation of the graphic pages.
- K. Project Closeout Submittals:
1. The controls contractor shall advise the Owner throughout the duration of construction as to the status of the contract closeout submittals including, but not limited to, the ongoing development of the maintenance and operations manuals and record documents.
 2. The Contractor shall assemble and submit as one package the following before making application for final payment.
 - a. Consent of Surety.
 - b. Documentation that Contractor returned University keys.
 - c. Documentation that Contractor returned signs reading, "Construction Staging Area, Vehicle Permit Required, Violators Will be Tagged and Towed."
 - d. Documentation that the Punch list is complete.
 - e. Executed Certificate of Occupancy (if required).
 - f. Executed TGB Total Payment Affidavit (if required).
 - g. Executed TGB Verification of Completed Work Affidavit (if required).
 - h. Executed Prevailing Wage Payment Affidavit (if required).
 - i. Evidence of Completed Operations Liability insurance coverage during the one-year correction period (if required).
 - j. Waste manifests, TCLP (Toxicity Characteristic Leachate Procedure), and OSHA monitoring results for asbestos or lead, as required by the Contract Documents (if required).

1.12 PROJECT RECORD DOCUMENTS

- A. General Requirements:
1. The Contractor shall maintain a set of Contract Documents at the site, on which variations shall be accurately marked with red erasable pencil on a daily basis. All changes, whether resulting from change orders, Architect's supplementary instructions, Contractor change directives, or other job noted changes, shall be recorded. The controls contractor shall periodically verify that this is being done satisfactorily.

B. Contract Drawings

1. Maintain a clean, undamaged set of blue or black line prints of Contract Drawings to use as the Project record documents.
2. Mark the drawing sets to show the actual installation where the installation varies substantially from the work as originally shown.
3. Give particular attention to recording concealed elements that will be difficult to measure and record at a later date. Also record new information that is important to the Owner but is not shown on Contract Drawings.
4. Note the related change order number where applicable.
5. Organize the record drawing sheets into manageable sets. Bind sets with durable-paper cover sheets; print the University Project Number and Name, and drawing numbers and titles on the cover sheet.

C. Record Project Manual

1. Maintain a clean, undamaged, complete set of the Project Manual to use as the Project record documents.
2. Include one copy of the addenda and other written documents issued during the construction period (Change Orders, RFIs, PRs, etc.) with the record Project Manual.
3. Contractor shall submit the Project record documents to the University for final inspection and comment at the completion of the job.
4. The final payment will not be made to the Contractor until the record documents and the Maintenance and Operating Manuals are received and approved in writing by the University.
5. Two months before expiration of the one-year correction period the controls contractor shall conduct a walk through and provide a written summary of findings and recommendations.
6. Submit electronic versions of all CAD drawings, points lists, and operating sequences. The electronic copies shall be stored on CDs and shall be saved in an editable format. Acceptable formats include Microsoft Office program formats (i.e. Word, Excel, Access, etc.), Visio, and AutoCAD. Other formats must be approved by the University at time of project award.

1.13 WARRANTY

A. Warrant all work as follows:

1. The warranty period for labor and material for the control system, including all subcontractor work, shall be 12 months after acceptance by Owner. The Owner's written acceptance will be given after verification testing demonstrates that the equipment is operating in accord with the contract documents. Minor deficiencies identified during testing that do not affect the functional performance of the equipment will not be used to deny acceptance for the purposes of determining the start of the warranty period.
2. During the warranty period, the Contractor shall respond to the Owner's request for warranty service within 24 hours during normal business hours.

3. For systems designated at critical, the Contractor shall respond to warranty service requests within 4 hours.
4. The Contractor shall correct all warranty repairs at no cost to the Owner.
5. The Contractor shall make all reasonable efforts to minimize the Owner's business disruption and loss associated with warranty repairs. This includes expedited shipping of materials, overtime work, night/weekend work, etc.
6. Software upgrades and service patches shall be made available and installed by the Contractor at no cost to the University during the warranty period.
7. The Contractor shall maintain a copy of the project database through the warranty period.

1.14 OWNERSHIP OF PROPRIETARY MATERIAL

- A. The Owner shall retain all rights to software for this project.
- B. The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to the Owner as defined by the manufacturer's license agreement, but shall protect the manufacturer's rights to disclosure of Trade Secrets contained within such software.
- C. The licensing agreement shall not preclude the use of the software by individuals under contract to the owner for commissioning, servicing, or altering the system in the future. Use of the software by individuals under contract to the owner shall be restricted to use on the owner's computers and only for the purpose of commissioning, servicing, or altering the installed system.
- D. All project developed software, files and documentation shall become the property of the Owner. These include but are not limited to:
 1. Server and Workstation software
 2. Application Programming Tools
 3. Configuration Tools
 4. Addressing Tools
 5. Application Files
 6. Configuration Files
 7. Graphic Files
 8. Report Files
 9. Graphic Symbol Libraries
 10. All Documentation.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Approved Manufacturers
 1. Johnson Controls

2. Siemens
 3. Trane
 4. University Approved Alternate
- B. Air flow/temperature measurement stations
1. Ebtron
 2. TekAir model Vortek
 3. Air Monitor VoluProbe
- C. Acceptable Installation Contractors
1. Branch offices and independent representatives for the above manufacturers must have a full staff of project managers, project engineers, system application engineers, application engineers and technicians. Branch offices and independent representatives must have a separate fully staffed service department to be an acceptable bidder.
 2. Approved Installation Contractors
 - a. Johnson Controls Branch Office – Minneapolis
 - b. Siemens Building Technologies Branch Office – Minneapolis
 - c. Trane Branch Office – Minneapolis
 3. Installation contractors not currently on the approved list may be considered if they meet the requirements of this specification. Financial stability and prior experience on University (or similar) projects will be considered by the Owner when selecting an installation contractor.

2.2 SYSTEM ARCHITECTURE

- A. The DDC system architecture shall consist of two layers, the TCP/IP layer and the field bus layer.
- B. The TCP/IP layer connects all of the buildings on a single dedicated and isolated network. Fixed IP addresses for connections to the University private DDC network shall be used for each device.
- C. BACnet Building Controllers (B-BC) shall be used to connect each field bus to the TCP/IP layer.

2.3 NETWORKING

- A. IP Network: All devices that connect to the WAN shall be capable of operating at 100 megabits per second.
- B. IP-to-Field Bus Routing Devices
 1. BACnet Building Controller shall be used to provide this functionality.
 2. These devices shall be configurable locally with RS232 or IP crossover cable and configurable via the IP network.
 3. The routing configuration shall be such that only data packets from the field bus devices that need to travel over the IP level of the architecture are forwarded.

- C. Field Bus
 - 1. The wiring of components shall use a bus or daisy chain concept with no tees, stubs, or free topology.
- D. Repeaters
 - 1. Where repeaters are required to connect two segments, repeaters shall be installed in an enclosure mounted in an accessible area.

2.4 BUILDING LEVEL CONTROLLERS (B-BC)

- A. Building level DDC controllers shall be microprocessor-based, multi-tasking, multi-user, real-time digital control processors fully capable of being integrated with the selected vendor's master work station, or any third party BACnet workstation.
- B. Building level DDC controllers shall utilize BACnet open standard communication protocol. All building level controllers shall communicate using BACnet/IP.
- C. A BACnet Building Controller (B-BC) as defined by ASHRAE Annex L is a general purpose, field programmable device capable of carrying out a variety of building automation and control tasks. It enables the specification of the following:
 - 1. Data Sharing
 - a. Ability to provide the values of any of its BACnet objects
 - b. Ability to retrieve the values of BACnet objects from other devices
 - c. Ability to allow modifications such as scheduling and present value of some or all of its BACnet objects by another device as shown in U of M required object table (see Appendix A).
 - 2. Alarm and Event Management
 - a. Generation of alarms / events notifications and the ability to direct them to recipients using the BACnet intrinsic alarming method
 - b. Maintain a list of unacknowledged alarms / events retrievable using standard BACnet Services
 - c. Maintain a list of alarms / events retrievable using standard BACnet Services
 - d. Notifying other recipients that the acknowledgment has been received
 - e. Adjustment of alarm / event parameters
 - 3. Scheduling
 - a. Ability to schedule output actions, both in the local device and in other devices, both binary and analog, based on date and time
 - 4. Trending
 - a. Collection and delivery of (time, value) pairs
 - 5. Device and Network Management
 - a. Ability to respond to information about its status
 - b. Ability to respond to requests for information about any of its objects

- c. Ability to respond to communication control messages
 - d. Ability to synchronize its internal clock upon request. (not required by U of M)
 - e. Ability to perform re-initialize upon request (not required by U of M)
 - f. Ability to upload its configuration and allow it to be subsequently restored
 - g. Ability to command half routers to establish and terminate connections (not required by U of M)
- D. If Building Controllers have embedded I/O, all of the requirements for I/O that are described under Unit Level Controllers shall apply.
- E. The temperature controls contractor's B-BC device(s) shall support all ANSI/ASHRAE 135-2004 standard object required and optional properties as listed in Appendix A. **BACnet intrinsic alarming is required.** All objects and object properties shall be supported so that alarms are sent from the temperature controls contractor's BACnet device without having to be solicited from the University BACnet Operators Workstation (BOWS) or U of M Master History PC.
- F. DDC panels and devices must utilize ANSI/ASHRAE 135-2004 BACnet Communications Protocol on a single building level network. BACnet communications must not cause derogated communications on the sites existing temperature control network. Derogation includes router, switch, or hub lockups, BACnet building controller lockups, excessive site network slowdowns, unnecessary and repeated 'who is' messages. Refer to ASHRAE BACnet standard for definition of unnecessary Who-is messages.
- G. U of M BACnet Required Protocol Services supported:
- 1. Acknowledge Alarm
 - 2. Confirmed Event Notify
 - 3. Get Alarm Summary
 - 4. Get Enrollment Sum
 - 5. Add List Element (for the purpose of allowing the addition of a recipient to the BB-C)
 - 6. Remove List Element (for the purpose of allowing the deletion of a recipient to the BB-C)
 - 7. Read Property
 - 8. Read Property Multiple
 - 9. Write Property
 - 10. Write Property Multiple
 - 11. Confirm Private Xfer
 - 12. I AM
 - 13. I Have
 - 14. Unconfirmed COV Notify

15. Unconfirmed Event Notify
 16. Time Synchronization
 17. Who Has
 18. Who Is
 19. UTC Time Sync
 20. Get Event Info
- H. All building controllers must be capable of having their databases uploaded, downloaded and viewed from the vendor's master workstation.
- I. All building level controllers shall have a local port that can connect to a laptop PC or other hand-held tool for local service work, troubleshooting, etc. Each controller shall include the capability to store, retrieve and print alarm summaries, trends and other critical point summaries or reports.
- J. Memory: Each DDC controller shall have sufficient memory to support its own operating system and databases and continuous trending on all analog points for that controller (AV, AI, AO) based on 300 sample intervals.
- K. Integrated On-line Diagnostics: Each DDC controller shall continuously perform self-diagnostics and communication diagnosis of all associated unit level equipment. The DDC controller shall provide both local and remote annunciation of any detected component failures, or repeated failure to establish communication. Indication of the diagnostic results shall be provided at each DDC controller and shall not require the connection of an auxiliary I/O device.
- L. Power Fail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of all DDC controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery back up shall be provided to support the real-time clock and all volatile memory for a minimum of seventy-two (72) hours. Upon restoration of normal power, the DDC controller shall automatically resume full operation without manual intervention. Should a DDC controller memory be lost for any reason, the user shall have the capability of reloading the DDC controller via the local area network or via the local interface port.
- M. System architectural design shall eliminate dependence upon any single device, front-end or higher level of controller for alarm reporting and control execution. Each DDC controller shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
- N. Building level DDC controllers shall be able to access any data from, or send control commands and alarm reports directly to any other building level controller or combination of controllers on the IP network without dependence upon a central processing device. Building level DDC controllers shall also be able to send alarm reports to multiple operator workstations without dependence upon a central processing device.
- O. All Ethernet network communications will use 100 MPS communication rates.

2.5 UNIT LEVEL CONTROLLERS

- A. Each Unit Level DDC controller shall consist of modular hardware with plug-in enclosed processors, communication controllers, power supplies, input and output (DI, DO, AI, AO) capabilities. A sufficient number of controllers shall be supplied to fully meet the requirements of this specification, the project drawings, and the point lists.
- B. Unit level DDC controllers shall utilize BACnet/MSTP or LON open standard communication protocol.
- C. All unit level controllers, including VAV controllers, must be able to have their databases uploaded, downloaded and viewed from the vendor's master workstation.
- D. Power Fail Restart: In the event of the loss of normal power, there shall be an orderly shutdown of all DDC controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data, and battery back up shall be provided to support the real-time clock and all volatile memory for a minimum of seventy-two (72) hours. Upon restoration of normal power, the DDC controller shall automatically resume full operation without manual intervention. Should a DDC controller memory be lost for any reason, the user shall have the capability of reloading the DDC controller via the local area network or via the local interface port.
- E. Each controller will be programmed such that each controlled device will have a default value in which to be commanded to in the event of a control sensor failure. The acceptable default values are, last command, full open, or full closed.
- F. Controller I/O Requirements
 - 1. Analog Input Circuits
 - a. The resolution of the A/D chip shall not be greater than 0.01 Volts per increment. For an A/D converter that has a measurement range of 0 to 10 VDC and is 10 bit, the resolution is 10/1024 or 0.00976 Volts per increment.
 - b. For non-flow sensors, the control logic shall support a calibration offset such that the raw measured value is added to the (+/-) offset to create a calibration value to be used by the control logic and reported to the Operator Workstation (OWS).
 - c. For flow sensors, the control logic shall provide support for the use of an adjustable gain and an adjustable offset such that a two point calibration concept can be executed (both a low range value and a high range value are adjusted to match values determined by a calibration instrument).
 - d. For non-linear sensors such as thermistors and flow sensors the controller shall provide software support for the linearization of the input signal.
 - 2. Binary Input Circuits
 - a. Dry contact sensors shall wire to the controller with two wires.
 - b. An external power supply in the sensor circuit shall not be required.
 - 3. Pulse Input Circuits

- a. Pulse input sensors shall wire to the controller with two wires.
 - b. An external power supply in the sensor circuit shall not be required.
 - c. The pulse input circuit shall be able to process up to 20 pulses per second.
4. True Analog Output Circuits
- a. The logical commands shall be processed by a digital to analog (D/A) converter chip. The 0% to 100% control signal shall be scalable to the full output range which shall be either 0 to 10 VDC, 4 to 20 milliamps or 0 to 20 milliamps or to ranges within the full output range.
 - b. The resolution of the D/A chip shall not be less than 0.04 Volts per increment or 0.08 milliamps per increment.
5. Binary Output Circuits
- a. Single pole, single throw or single pole, double throw relays.
 - b. Voltage sourcing or externally powered triacs with support for up to 30 VAC and 0.5 amps at 24 VAC.
6. Program Execution
- a. Process control loops shall operate in parallel and not in sequence unless specifically required to operate in sequence by the sequence of control.
 - b. The sample rate for a process control loop shall be adjustable and shall support a maximum sample rate of 1 second.
 - c. The sample rate for process variables shall be adjustable and shall support a maximum sample rate of 1 second.
 - d. The sample rate for algorithm updates shall be adjustable and shall support a maximum sample rate of 1 second.
 - e. The application shall have the ability to determine if a power cycle to the controller has occurred and the application programmer shall be able to use the indication of a power cycle to modify the sequence of controller immediately following a power cycle.
7. Local Interface: The controller shall support the connection of a portable interface device such as a laptop computer or vendor specific hand-held device. Via this local interface, an operator shall be able to:
- a. Adjust application parameters.
 - b. Execute manual control of input and output points.
 - c. View dynamic data.
- G. Unit level controllers shall not be dependent upon any other controller (unit or building level) to maintain safe operation of the controlled equipment.
- H. All unit level controllers and/or enclosures shall be clearly labeled with their Node address. Tag all wiring on the DDC side of the interface panel identifying the associated point.

- I. **PROHIBITED:** Transmitting process variable data via the IP network or field bus for use in PID control loops. Data transmitted from point expansion modules to unit controllers via a dedicated point expansion communication bus is allowed.
- J. **PROHIBITED:** Splitting mechanical systems between more than one Unit Level controller without prior approval from Owner.

2.6 OPERATOR WORKSTATION (OWS)

- A. The Operator Interface Workstations will comprise a Personal Computer (PC) together with operator terminals. The PC will be a fully integrated node on the management level network and shall provide the operator with a graphical interface into the entire network. The monitoring and control functions of the BMCS shall be totally independent of the PC such that if the PC is not operational there shall be no impact on the building control systems except for the reduced operator interface capability at that location.
- B. Provide OWS at the following locations:
 - 1. Location TBD.
- C. Provide OWS meeting, at minimum, the following requirements:
 - 1. Intel motherboard with single Intel Core 2 Duo processor with a minimum speed of 3.0 GHz and 4 MB L2 Cache.
 - 2. 2 Gigabyte of memory.
 - 3. One 160 Gigabyte SATA hard drive.
 - 4. Tower or desktop style case.
 - 5. 4 USB ports.
 - 6. 48x32xCDRW and 16xDVD+/-RW.
 - 7. Auto sensing full duplex 10/100/1000 Ethernet network interface card (NIC).
 - 8. USB style connectors for keyboard and mouse.
 - 9. 256 Megabyte video RAM.
 - 10. All necessary mounting hardware and cables for all components.
 - 11. Integral power supplies which shall be suitably rated for the service.
 - 12. Real time software or hardware clock.
 - 13. 1.44 Floppy disk drive
- D. Provide a Video Display Unit (VDU) meeting, at minimum, the following requirements:
 - 1. Flat panel LCD display with screen diagonal measurement of no less than 19 inches.
 - 2. Resolution of .28 pitch, 1280 by 1024 pixels with 85Hz minimum refresh rate.
 - 3. Capable of displaying both schematic and alphanumeric data at the same time.
 - 4. 16 million discrete colors.
 - 5. Manufactured by NEC, Viewsonic, Sony, Samsung, or approved equal.

2.7 DDC SYSTEM SOFTWARE

A. BACnet Operator Workstations

1. Hardware Communication Function

- a. The OWS shall extract data from the hardware environment and move the data to the data server and/or present the data to the presentation system.
- b. The OWS shall extract data from the data server and present the data to the data presentation system.
- c. The OWS shall track operator actions at the presentation system and write a record of activities to the data server.

2. BACnet Compliance

- a. The OWS shall be able to initiate a “Who Is” request to the network.
- b. The OWS shall respond to a “Who Is” request from another BACnet device with an “I Am” response.
- c. The OWS shall be able to read binary and analog data from BACnet devices that support the reading of data.
- d. The OWS shall be able to write binary and analog data to BACnet devices that support the writing of data from a BACnet OWS.
- e. The OWS shall be able to receive alarm messages from BACnet devices that export alarm messages.
- f. The OWS shall be able to acknowledge alarms from BACnet devices.
- g. The OWS shall be able to edit time schedule parameters in BACnet devices that support the editing of time schedule parameters from a BACnet OWS.
- h. The OWS shall be able to retrieve a collection of trend samples from a BACnet device that stores the data and permits the export of that data to a BACnet OWS.
- i. The OWS shall be able to initiate time synchronization commands to all BACnet devices that support the receipt of time synchronization commands from a BACnet OWS.

3. Data Presentation: Data shall be presented in the following formats.

- a. Points lists with dynamic presentation of data. The operator shall be able to create custom point lists with data that originates from multiple devices. A point may be dynamic data from a controller or a configuration parameter to be written to a controller by the operator.
- b. Graphic pages with dynamic presentation of data on a visual diagram that represents a building, a floor plan, a cross section of a mechanical system or a table of data.
- c. Graphical presentation of historical trend log data plotted against time.
- d. Graphical presentation of real time trend data plotted against time.
- e. Alarm Presentation

- (1) Unless restricted by a reduction in viewing authority, an operator shall be able to view alarms for all systems in a single alarm list.
 - (2) Custom alarm views configured for select categories of alarms shall present only the alarms specified.
 - (3) Alarm messages shall include identifying information and the signal value or state at the time of the alarm.
 - f. Event Presentation
 - (1) Unless restricted by a reduction in viewing authority, an operator shall be able to view an event log that chronologically captures all activity created by the system and operator actions.
 - (2) Custom event views for select categories of events shall present only the events specified.
 - g. Time Schedules
 - (1) Each time schedule shall have the ability to issue a minimum of 10 start and 10 stop commands for the week. The requirements for start and stop commands may be different for each day of the week.
 - (2) Each time schedule shall also include a holiday component where a holiday is identified by the date and duration (one day, two days, etc.). The time schedule shall support a unique set of start and stop commands for each holiday. The time schedule shall support a minimum of 20 holidays per year. Holiday schedules shall take precedence over standard schedules during the holiday period. Holidays that are date specific shall roll over from year to year without operator programming action.
 - (3) There shall be a mechanism to link a master time schedule editor at an OWS to multiple time schedules in various Building Controllers. Once linked, whenever the master time schedule is changed at an OWS, the new time schedule parameters shall be downloaded to all of the linked time schedules. This concept shall apply to both standard schedules and holiday schedules.
 - h. The system shall support a configuration that:
 - (1) Causes the system to go into standby mode (user is logged out but the current screen is still displayed) after a specific period of inactivity.
 - (2) Automatic system logout after a specific period of inactivity.
4. Data Source
 - a. An operator workstation shall present data from the entire hardware environment.
 - b. The system architecture shall provide for a minimum of 25 concurrent operator workstations per system.
5. Operator Access And Privileges
 - a. There shall be a minimum of four privilege levels.
 - (1) System Administrator
 - (a) No limitations
 - (b) Only level that can assign or delete users and assign or modify privileges.

- (2) Engineer
 - (a) View data in any format.
 - (b) Acknowledge alarms.
 - (c) Inhibit alarms.
 - (d) Exercise control actions.
 - (e) Edit the presentation of data.
 - (f) Modify the system.
- (3) Operator
 - (a) View data in any format.
 - (b) Acknowledge alarms.
 - (c) Exercise control actions.
- (4) Viewer
 - (a) View data in any format.
- b. The level assigned to a specific user shall be the maximum level that can be used any where in the system. The software shall provide the capability to reduce a user's level from his or her maximum level to a lower level on a per building or system basis. This may be accomplished on a per object basis within the database or by the application of additional security levels beyond the basic four levels.
- c. Signing on to the system shall require a user name and password. When the password is typed in, it shall not be shown on the screen.
- d. The software shall provide the capability to establish groups of users with the same privileges. Once assigned to the group, the user shall automatically have the maximum privileges and the selectively reduced privileges assigned to the group.
- e. The software shall provide the capability to set user profiles that enable assigning a specific home graphic page, alarm view, and event view.
- 6. Operator Actions
 - a. Given the appropriate authority, an operator from an operator workstation shall be able to:
 - (1) View all data that is presented in the forms described previously.
 - (2) Acknowledge alarms.
 - (3) Manually control both physical input and physical output points.
 - (4) Edit both independent and master time schedules.
 - (5) Initiate real time trend logging.
 - (6) Manually initiate reports.
 - (7) Initiate system backups for the database and trend log data.
 - (8) Customize the layout of the operator workstation presentation which shall then be the default for that user.
 - b. The operator shall be able to execute the above tasks on data from any of the operator workstations.
 - c. The system shall support the use of Electronic Signature system wide or on a per user basis.
 - d. All of the operator workstations shall be operable simultaneously.
- 7. Engineering Actions

- a. The software shall, as a minimum, enable the following engineering functions from each of the operator workstations:
 - (1) Create graphic pages for the presentation of dynamic data on visual images of buildings or equipment.
 - (2) Create reports for the presentation of historical data in an organized format.
 - (3) Create time schedules.
 - (4) Create trend logs in any of the field level devices and assign a dynamic variable from a field bus device to be trended.
 - (5) Setup long term storage of trend log data on the data server computer and the automatic transfer of the trend log data to the data storage tables in the long-term database.
 - (6) Create alarm objects in any of the field level devices, assign an alarm variable from a field bus device to initiate the alarm and set up the alarm routing.
 - (7) Configure and bring on-line a newly installed Building Controller in support of an initial or incrementally added building control system.
 - (8) Configure and bring on-line a newly installed field level devices in support of an initial or incrementally added building control system.
 - (9) Create and download applications for programmable devices.
 - (10) Download firmware updates to field level devices.
 - (11) Import all field level devices into the system so that all input network variables, output network variables and adjustable application parameters can be accessed from any of the operator workstations.
 - (12) Establish data flow from one field level device to a second field level device.
 - (13) Establish data flow from a field bus device under one IP connection to a field bus device under a different IP connection.
 - (14) Configure the system to create backups of the database and all application and supporting databases on a scheduled basis.
 - (15) Setup user groups and individual users and establish authority levels for each group and individual user.
 - (16) Any additional tasks defined later in this document or required to deliver a fully functional system.

B. Graphic Page Creation and Editing

1. The Graphics Editor portion of the Engineering Software shall provide the following minimum capabilities:
 - a. Create and save symbols.
 - b. Create and save pages.
 - c. Group and ungroup symbols.
 - d. Modify an existing symbol.
 - e. Modify an existing graphic page.
 - f. Rotate and mirror a symbol.
 - g. Place a symbol on a page.

- h. Place analog dynamic data in decimal format on a page.
- i. Place binary dynamic data using state descriptors on a page.
- j. Create motion through the use of gif, jpeg, bmp or svg files
- k. Place test mode indication on a page.
- l. Place manual mode indication on a page.
- m. Place links using a fixed symbol or flyover on a page.
 - (1) Links to other graphics.
 - (2) Links to web sites.
 - (3) Links to notes.
 - (4) Links to time schedules.
 - (5) Links to trends.
- n. Assign a background color.
- o. Assign a foreground color.
- p. Place alarm indicators on a page.
- q. Change a symbol color as a function of an analog variable.
- r. Change a symbol color as a function of a binary state.
- s. Change symbols as a function of a binary state.
- t. All symbols used by the contractor in the creation of graphic pages shall be saved to a library file for use by the owner.

C. Event Logging

- 1. The system shall maintain a log of all operator activity, system messages, alarms, and alarm acknowledgments.
- 2. Operator activity is defined as any action by an operator such as changing the value of an application parameter, modifying a program, acknowledging an alarm, logging on, logging off, etc. Any change in the system caused by operator action shall be part of the log. The log shall include the event, the time of the event, the part of the system affected, and an identification of the operator and the OWS from which the change was made.
- 3. When the event deals with a value change, both the original and new values shall be part of the event record.
- 4. The Event Log shall be exportable to a report format that is printable.
- 5. The System Administrator shall be able to archive the event log.
- 6. The event data shall comply with 21 CFR Part 11 requirements for data integrity.
- 7. The Event Log shall have a search function with assignable criteria to identify subsets of the event log such as all points placed under manual control, etc.

D. Alarm Generation And Processing

- 1. Alarm creation is a two part process. The creation of a binary alarm indication is accomplished in a field level device where a binary state of zero shall indicate a normal condition and a binary state of one shall indicate an alarm condition. The binary alarm condition is read within a B-AAC, or Building Controller. The B-

- AAC or Building Controller shall assign a descriptive message, a category or priority number and a date and time stamp to the alarm and forward the information to the OWS in accordance with an alarm routing table.
2. Alarm parameters such as high limits, low limits, time to state, binary alarm conditions are setup within the programming of the field level devices. These parameters shall be viewable and editable in point lists and on configuration graphic pages.
 3. The alarm message shall be descriptive.
 - a. Building identification
 - b. System identification
 - c. Device identification
 - d. Date
 - e. Time to the second
 - f. Nature of the alarm
 - (1) High value
 - (2) Low value
 - (3) Fail to start
 - g. Value or state at the time of the alarm.
 4. When the operator acknowledges the alarm, there shall be an opportunity to enter a message that becomes a permanent part of the alarm record recorded in the event log.
 5. The system shall support the association of graphic pages, trend charts, reports and text documents with specific alarms.
 - a. The operator shall have the ability to configure the system to auto-launch a specific graphic page when the alarm occurs.
 - b. The system shall support the assignment of wav files to alarm signals on graphic pages.
 - c. The operator shall have the ability to launch a specific trend chart from the alarm window when the alarm occurs.
 - d. The operator shall have the ability to launch a specific text document when the alarm occurs.
 - e. An associated report shall automatically execute and write to the hard disk on the OWS when the alarm occurs. Configurations options shall include overwriting the previous report or creating a new file.
 6. The system shall use selectable multiple colors on alarm messages for each of the following conditions:
 - a. Alarm condition exists and has not been acknowledged
 - b. Alarm condition has returned to normal but was never acknowledged
 - c. Alarm condition exists and has been acknowledged

7. When an alarm condition no longer exists and has been acknowledged, it shall no longer be displayed in the alarm viewer but it shall be permanently recorded in the event list.
8. The Alarm Routing Table shall support the following:
 - a. Multiple workstations at any time.
 - b. Specific workstations at particular times (to include all of the time as one choice).
 - c. Pagers
 - d. Email addresses via simple mail transfer protocol (SMTP; RFC 821)
 - e. Permanent comprehensive system wide alarm file
 - f. Specific alarm file based on a building or equipment identification
 - g. One or more alarm printers at any time
 - h. Specific alarm printers at specific times
 - i. Rerouting of alarms to a backup receiver when an acknowledgement has not been entered into the system within a specified time.
9. The system shall have a default audible indicator generated by the computer when an alarm is received.
10. Once an alarm is acknowledged at one OWS, it shall display as acknowledged at all operator workstations.
11. An operator shall be able to select multiple alarms for single action acknowledgement.
12. There shall be the ability to disable alarms.
13. The OWS alarm viewer shall be able to display the last 100 active alarms. If there are more than 100 active alarms, as alarms are acknowledged and removed from the viewer, older alarms shall be viewable to keep the viewer showing the last 100 active alarms until there are less than 100 active alarms.

E. Trends

1. Real Time Trends:
 - a. At each OWS the operator shall be able to initiate a real time trending instance of up to 10 variables simultaneously.
 - b. The polling interval setting shall be adjustable down to a rate of every second.
 - c. The data for each instance shall be presented on a single graphical display that automatically updates with each new data collection cycle.
 - d. The graphical presentation shall plot the variables on the Y axis and time on the X axis.
 - e. A minimum of two Y axis scales shall be available.
 - f. The operator shall have the ability to set the range on each Y axis scale or let the scales auto range to cover the range of the values being trended.

- g. Each element of data on the graphical display must be labeled by name or by a unique color. If color is used, a color legend must be included on the graph.
 - h. The operator shall be able to open up to five instances simultaneously for a total of 100 points being trended at one time.
 - i. An operator shall be able to print an instance of real time data.
 - j. The system shall be capable of trending any variable in the system.
 - k. The operator shall be able to save pre-configured instances of real time trending that can be initiated with simple point and click actions.
2. Historical Data Collection:
- a. Historical trend data shall be collected by field level devices and periodically uploaded to the data server.
 - b. The trend log objects in the field level devices shall have the capacity to store 300 samples per variable. When the 301st sample is collected, the 1st sample shall be discarded.
 - c. The field level devices shall be configured to request an upload of data when the number of samples is not greater than 180. Uploads may be configured to occur at a greater frequency.
 - d. Initiation of historical data collection shall be configurable.
 - (1) By manual operator intervention in a point and click manner.
 - (2) By a user adjustable time schedule or date.
 - (3) Triggered by a binary status variable (when the fan status is on, start the trend of the mixed air temperature).
 - (4) The system shall be capable of trending any variable in the system.
 - e. The status and capacity of the trend logs in the field devices shall be viewable from the operator workstation.
3. Historical Data Presentation:
- a. An OWS shall have the capability to present the historical data for a variable in a tabular presentation of the values along with the date and time of the sample. The time period for the values to be presented shall be user adjustable.
 - b. An OWS shall have the capability to present the historical data for a variable in a graphical presentation of the values plotted against time and date.
 - c. The graphical presentation capabilities for historical trends shall equal those described above for real time trends.
 - d. The operator shall be able to save pre-configured instances of historical trending that can be initiated with simple point and click actions.
 - e. The operator shall be able to print the tabular presentations and graphical presentations of historical trend data.
4. The data collection, storage, retrieval and presentation system shall provide the features necessary for the owner to achieve certification under 21 CFR Part 11.

The key issue is the integrity of the data, the ability to verify that the data has not been modified after collection by the system.

F. Application Programming

1. The application programming tool may be based on Line Programming or Graphical Programming concepts.
2. If the application programming is object based and graphical:
 - a. There shall be an off-line simulation capability.
 - b. There shall be the ability to view dynamic data displayed on the object diagram in real time.
3. There shall be self checking for errors in programming to be used by the programmer.
4. Key functions that must be supported are:
 - a. Timer functions to include Delay Off, Delay On and Sample Rate Support
 - b. Interval timer
 - c. Math functions to include Addition, Subtraction, Multiplication, Division, Exponentiation, Trigonometric Functions and Logarithmic Functions (base 2 and base 10)
 - d. If-Then-Else Instructions (also referred to as switching logic)
 - e. Look up tables with a minimum of 100 entries, with and without extrapolation
 - f. Bit Wise Logic
 - g. Sample and hold binary
 - h. Sample and hold analog
 - i. Latch on and latch off functions with resets
 - j. Input network variable definition
 - k. Output network variable definition
 - l. Sensor measurement definition
 - m. End device control definition
 - n. Logic functions to include And, Or, Not and Exclusive Or
 - o. Detection of a power cycle
 - p. Common function support (standard objects in graphical programs and subroutines in line programs). As a minimum the common functions shall include:
 - (1) PID with analog output
 - (2) PID with tri-state outputs
 - (3) Enthalpy from temperature and relative humidity
 - (4) Optimum start stop based on occupancy schedule, temperature, set point and outside air temperature.
 - (5) Polynomial equation

G. Report Creation

1. The operators shall be able to extract historical data from the data collection files and present the data in a Microsoft Excel format. All of the data in the log shall be exportable to include the date, time and values.
2. The number of trend logs that can be inserted into a single Excel Workbook shall not be limited by the OWS software.
3. The operators shall be able to pre-configure reports for manual execution or automated execution.
4. The OWS shall be able to auto execute any report based on:
 - a. A time schedule
 - b. An alarm trigger
 - c. The status of a binary point (state=1, execute the report)
5. The operators shall be able to pre-configure the destination of the report:
 - a. OWS screen
 - b. Write to file on the hard drive
 - c. Send to a printer.
6. The generation of a report shall not interrupt the use of the OWS by the operator, that is, it shall execute in the background.

2.8 ENCLOSURES AND WEATHER SHIELDS

A. Enclosures shall meet the following minimum requirements:

1. Outdoors: Enclosures located outdoors shall meet NEMA Type 4 requirements.
2. Mechanical and Electrical Rooms: Enclosures shall meet NEMA 250 Type 12 requirements. If no water source is located above or closer than 20 feet horizontally from the panel location a Type 1 enclosure can be used with prior approval from the Owner.
3. Wet Locations: Enclosures shall meet NEMA 250 Type 4 requirements.
4. All Other Dry Locations: Enclosures shall meet NEMA 250 Type 1 requirements.
5. All panels shall be self-supporting enclosures with keyed lock
6. Each panel shall be UL/ETL listed and stamped.

B. Weather shields shall meet the following minimum requirements:

1. They shall prevent the sun from directly striking the sensor.
2. They shall provide sufficient ventilation so that the sensing element measures the ambient conditions of the surroundings.
3. They shall prevent rain from directly striking or dripping onto the sensor.
4. When installed near outside air intake ducts, they shall be installed such that normal outside air flow does not cause rainwater to strike the sensor.

5. They shall be unpainted aluminum or they shall be white galvanized steel aluminum or PVC.

2.9 WIRE, CABLE, AND TRANSFORMERS

- A. Refer to Division 16 for conduits and conductors, except as noted.
- B. All wire and cable shall meet the requirements of NFPA 70 and NFPA 90A.
- C. Terminal blocks, which are not integral to other equipment, shall be insulated, modular, feed-trough, clamp style with recessed captive screw-type clamping mechanism, shall be suitable for rail mounting, and shall have end plates and partition plates for separation or enclosed sides.
- D. Control wiring for binary sensors shall be 18 AWG copper and shall be rated for 300-volt service.
- E. Wiring for 120-volt circuits shall be 18 AWG or thicker stranded copper and shall be rated for 600-volt service.
- F. Control wiring for analog signals shall be 18 AWG, copper, multiple strand, twisted (minimum 50 mm lay of twist), and shall have 300 volt insulation. For applications requiring shielded cable, each pair shall have a 20 AWG tinned-copper drain wire and individual overall pair insulation.
- G. IP Network cable shall meet or exceed all requirements of Category 5 cable as specified in ANSI/TIA/EAI 568-A.
- H. Transformers shall be UL 1585 approved and shall be sized so that the connected load is no greater than 80% of the transformer rated capacity.

2.10 SENSORS

- A. Space Temperature Sensors: Vibration and corrosion resistant for wall mounting as required.
 1. Room Sensor T-1: Provide low mass resistance temperature detector type room sensors suitable for wall mounting in a vertical position.
 - a. Accuracy: Plus or minus 0.2 percent of full scale at calibration point.
 - b. Sensing Range: 32 to 120 deg F.
 - c. Setpoint Scale Range: 60 to 90 deg F.
- B. Electronic Sensors: Vibration and corrosion resistant; for immersion, wall, or duct mounting as required.
 1. Resistance Temperature Detectors: Platinum.
 - a. Accuracy: Plus or minus 0.2 percent of full scale at calibration point.
 - b. Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.
 - c. Averaging Elements in Ducts: Minimum of 36 inches long, flexible; use where prone to temperature stratification or where ducts are larger than 9 sq. ft; length as required.

- d. Insertion Elements for Liquids: Brass socket with minimum insertion length of **2-1/2 inches**.
- e. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
2. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
 - a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
 - b. Output: 4 to 20 mA.
 - c. Building Static-Pressure Range: 0 to 0.25 inch wg.
 - d. Duct Static-Pressure Range: 0 to 5 inches wg.
3. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; proportional output 4 to 20 mA.
- C. Equipment operation sensors as follows:
 1. Status Inputs for Pumps: Differential-pressure switch piped across pump with adjustable pressure-differential range of **8 to 60 psig**.
 2. Status Inputs for Electric Motors: Current-sensing relay with current transformers, adjustable and set to 175 percent of rated motor current.
- D. Water-Flow Switches: Pressure-flow switches of bellows-actuated mercury or snap-acting type, with appropriate scale range and differential adjustment, with stainless steel or bronze paddle. For chilled-water applications, provide vapor proof type.

2.11 THERMOSTATS

- A. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.
- B. Electric Low-Limit Duct Thermostat: Snap-acting, double-pole, single-throw, manual-reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below set point.
 1. Bulb Length: Minimum **20 feet**.
 2. Quantity: One thermostat for every **25 sq. ft.** of coil surface.
- C. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature, with copper capillary and bulb, unless otherwise indicated.
 1. Bulbs in water lines with separate wells of same material as bulb.
 2. Bulbs in air ducts with flanges and shields.
 3. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
 4. On-Off Thermostat: With precision snap switches, with electrical ratings required by application.

5. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.

2.12 AIR FLOW/TEMPERATURE MEASUREMENT STATIONS

- A. Airflow/temperature measurement stations (AFTMS): AFTMS shall be located where indicated on the plans and 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. Each sensor probe shall be provided with a UL plenum-rated connecting cable. Connecting cable shall be a minimum of 10 feet in length for each probe. No additional devices or transducers shall be required to interface with the host controls. Sensors shall be calibrated to NIST-traceable standards for both airflow and temperature. Each sensing point shall independently measure airflow and temperature prior to averaging. Installed accuracy shall be percent of reading and demonstrated at both maximum and minimum airflow rates for each measurement location.
- B. Electronics Enclosure: The enclosure shall be aluminum alloy for indoor use and capable of operating over a temperature range of +30° F to +120° F. The electronics shall be installed inside and protected from the weather.
- C. Transmitter: The transmitter shall operate on 24-V ac. 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 V-dc or 4-20 mA). When required on the plans, a serial RS-485 interface will be made available with network protocols of either N2 or ModBus RTU, as required by the DDC control equipment. All inputs and outputs shall be fused, protected, and internally isolated from the 24-V ac 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 or LPS.
- D. Duct & Plenum Mounted Sensor Probes: Sensor probes shall be constructed of anodized aluminum alloy tube with stainless steel mounting brackets. Probes shall be constructed to provide insertion, internal, or standoff mounting, depending on the applications and field installation requirements.
 1. Performance Requirements: The sensor accuracy for airflow shall be at least $\pm 2\%$ of Reading over the sensor probe operating ranges. The installed total accuracy for airflow shall be better than $\pm 3\%$ of Reading over the sensor probe operating ranges when installed in accordance with manufacturers' guidelines. The sensor accuracy for temperature shall be better than $\pm 0.15^\circ$ F over the entire operating range. Each sensing point shall independently measure airflow and temperature prior to averaging.
 2. Probe Sensor Spacing and Density: The number of independent sensing points shall be distributed per duct face area, at a minimum quantity as indicated below.
 - a. Duct Area, 1 ft² and smaller, 2 sensing points.
 - b. Duct Area, greater than 1 ft² and less than 4 ft², 4 sensing points.
 - c. Duct Area, 4 ft² and greater but less than 8 ft², 6 sensing points.

- d. Duct Area, 8 ft² and greater but less than 12 ft², 8 sensing points.
 - e. Duct Area, 12 ft² and greater but less than 16 ft², 12 sensing points.
 - f. Duct Area, 16 ft² and greater, 16 sensing points.
3. Probe Operation Ranges:
- a. Airflow: 0 to 5,000 FPM
 - b. Temperature: -20° F to +160° F
 - c. Relative Humidity: 0 to 99% (non-condensing)
- E. Fan Inlet Velocity Sensors: Sensors shall be totally constructed from non-corrosive materials, with stainless steel sensor bodies, stainless steel mounting brackets and with adjustable cadmium-plated mounting rods.
1. Fan Inlet Performance Requirements: The individual sensor accuracy for airflow shall be better than $\pm 3\%$ of Reading over the sensor probe operating ranges when installed in accordance with manufacturers' guidelines. The installed accuracy for temperature shall be better than $\pm 0.15^\circ$ F over the entire operating range.
 2. Fan Inlet Sensor Operating Ranges:
 - a. Airflow: 0 to 10,000 FPM
 - b. Temperature: -20° F to +160° F
 - c. Relative Humidity: 0 to 99% (non-condensing)

2.13 ACTUATORS

- A. Electronic Actuators: Direct-coupled type designed for minimum 100,000 full-stroke cycles at rated torque.
1. Valves: Size for torque required for valve close-off at maximum pump differential pressure.
 2. Dampers: Size for running torque calculated as follows:
 3. Parallel-Blade Damper with Edge Seals: 7 inch-pounds/sq. ft. of damper.
 4. Opposed-Blade Damper with Edge Seals: 5 inch-pounds/sq. ft. of damper.
 5. Parallel-Blade Damper without Edge Seals: 4 inch-pounds/sq. ft. of damper.
 6. Opposed-Blade Damper without Edge Seals: 3 inch-pounds/sq. ft. of damper.
 7. Dampers with 2 to 3 Inches wg of Pressure Drop or Face Velocities of 1000 to 2500 FPM: Multiply the minimum full-stroke cycles above by 1.5.
 8. Dampers with 3 to 4 Inches wg of Pressure Drop or Face Velocities of 2500 to 3000 FPM: Multiply the minimum full-stroke cycles above by 2.0.
 9. Coupling: V-bolt and V-shaped, toothed cradle.
 10. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 11. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on non-spring-return actuators.
 12. Power Requirements (Two-Position Spring Return): 24-V ac.
 13. Power Requirements (Modulating): Maximum 10 VA at 24-V ac.

14. Proportional Signal: 2- to 10-V dc or 4 to 20 mA.
15. Temperature Rating: Minus 22 to plus 122 deg F.
16. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F.
17. Humidity Rating: 0 to 95% RH, non-condensing.
18. Run Time: 90 seconds.

2.14 VAV CONTROLS

- A. VAV controllers, flow transducers, and damper actuators shall be provided by this contractor and shipped to the VAV air terminal unit manufacturer for factory mounting. Control wiring and device enclosures shall be plenum rated.
- B. VAV Controllers:
 1. Operating Voltage: 24-V ac.
 2. Frequency: 60 hz.
 3. Power Requirements: Maximum 6 VA at 24-V ac.
 4. Proportional Signal: 2- to 10-V dc or 4 to 20 mA.
 5. Temperature Rating: Minus 22 to plus 122 deg F.
 6. Humidity Rating: 0 to 95% RH, non condensing
 7. Surge Suppression: All inputs/outputs shall be protected against lightning-induced surge or voltage transients
- C. Flow Transducers:
 1. Range: 0.01 to 2 in wg.
 2. Flow Sensing: Flow compensated differential pressure transducer
 3. Input: Two ¼” plastic tubing connections to velocity sensor for measurement of static and total pressure.
- D. Electronic Damper Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 1. Size for minimum running torque of 44 lb-in.
 2. Coupling: V-bolt and V-shaped, toothed cradle.
 3. Fail-Safe Operation: Provide external, manual gear release.
 4. Operating Voltage: 24-V ac.
 5. Frequency: 60 hz.
 6. Power Requirements (Modulating): Maximum 10 VA at 24-V ac.
 7. Proportional Signal: 2- to 10-V dc or 4 to 20 mA.
 8. Temperature Rating: Minus 22 to plus 122 deg F.
 9. Humidity Rating: 0 to 95% RH, non-condensing.
 10. Run Time: 90 seconds.

2.15 CONTROL VALVES

- A. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
- B. Globe Valves NPS 2 and Smaller: Bronze body, stainless stem, rising stem, renewable composition disc, and screwed ends with backseating capacity re-packable under pressure.
- C. Globe Valves NPS 2-1/2 and Larger: Iron body, stainless stem, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
- D. Hydronic system globe valves shall have the following characteristics:
 - 1. Rating: Class 125 for service at 125 psig and 190 deg F operating conditions.
 - 2. Internal Construction: Replaceable plugs and seats of stainless steel or brass.
 - a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
 - b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.
 - 3. Sizing: 5-psig maximum pressure drop at design flow rate.
 - 4. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics. Operators shall close valves against pump shutoff head.
- E. Steam system globe valves shall have the following characteristics:
 - 1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
 - 2. Internal Construction: Replaceable plugs and seats of stainless steel.
 - a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
 - b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.
 - 3. Sizing: 10-psig inlet pressure and 5-psig pressure drop.
 - 4. Flow Characteristics: Modified linear characteristics.
- F. Terminal Unit Control Valves: Bronze body, stainless stem, two- or three-port as indicated, replaceable plugs and seats, union and threaded ends.
 - 1. Rating: Class 125 for service at 125 psig and 250 deg F operating conditions.
 - 2. Sizing: 3-psig maximum pressure drop at design flow rate, to close against pump shutoff head.
 - 3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

2.16 DAMPERS

- A. Outside and Relief Air Dampers (Insulated): The dampers specified below shall be used for modulating and two position control of outside, relief, and exhaust air.

1. Fabrication:
 - a. Frame: 5 in. x 1 in. 16 ga. galvanized steel hat channel. Reinforced corners.
 - b. Blades:
 - (1) Style: Insulated, airfoil shaped, filled with ½ in. polystyrene.
 - (2) Action: Parallel or opposed blade as indicated on control drawings.
 - (3) Orientation: Horizontal or vertical with thrust washers.
 - (4) Material: Galvanized steel double skin construction 14 ga. equivalent thickness
 - (5) Width: Maximum 6 inches.
 - c. Bearings: Synthetic (acetal) sleeve type.
 - d. Seals:
 - (1) Blade: Extruded silicone blade seals mechanically attached to blade edge.
 - (2) Jamb: Extruded silicone.
 - e. Linkage: Concealed in frame.
 - f. Axles: Minimum 1/2-inch diameter plated steel, hex-shaped, mechanically attached to blade.
 - g. Mounting: Vertical or horizontal as shown on drawings or as required for serviceable installation.
 - h. Finish: Galvanized steel.
 2. Performance Data:
 - a. Temperature Rating: Withstand -72 to 275 degrees F.
 - b. Capacity: Demonstrate capacity of damper to withstand HVAC system operating conditions.
 - (1) Closed Position: Maximum pressure of 8.0 inches w.g. at a 12-inch blade length.
 - (2) Open Position: Maximum air velocity of 4,000 feet per minute.
 - c. Leakage: Maximum 6.0 cubic feet per minute per square foot at 4 inches w.g. for size 48 x 48 inches.
 - d. Pressure Drop: Maximum 0.07 inch w.g. at 1,500 feet per minute across 24 inch x 24 inch damper in a fully ducted configuration as tested per AMCA Standard 500.
- B. Return Air Dampers (Non-insulated): The dampers specified below shall be used for modulating and two position control of return, mixed, and supply air.

1. Fabrication:
 - a. Frame: 5 inches x 1 inch x minimum 0.125 inch (127 x 25 x minimum 3.2 mm) 6063-T5 extruded aluminum hat-shaped channel, mounting flanges on both sides of frame, reinforced at corners.
 - b. Blades:
 - (1) Style: Airfoil-shaped, single-piece.

- (2) Action: Parallel or opposed blade as indicated on control drawings.
 - (3) Orientation: Horizontal or vertical with thrust washers.
 - (4) Material: Heavy duty 6063-T5 extruded aluminum.
 - (5) Width: Maximum 6 inches.
 - c. Bearings: Molded synthetic sleeve, turning in hole in frame.
 - d. Seals:
 - (1) Blade: Inflatable seal blade edging, or replaceable rubber seals for ultra-low leakage from -72 to 275 degrees F. Mechanically attached to blade edge.
 - (2) Jamb: Flexible metal compression type.
 - e. Linkage: Concealed in frame.
 - f. Axles: Minimum 1/2 inch diameter plated steel, hex-shaped, mechanically attached to blade.
 - g. Mounting: Vertical or horizontal as shown on drawings or as required for serviceable installation.
 - h. Finish: Mill aluminum.
2. Performance Data:
- a. Temperature Rating: Withstand -72 to 275 degrees F.
 - b. Capacity: Demonstrate capacity of damper to withstand HVAC system operating conditions.
 - (1) Closed Position: Maximum pressure of 13 inches w.g. at a 12-inch blade length.
 - (2) Open Position: Maximum air velocity of 6,000 feet per minute.
 - c. Leakage: Maximum 5.2 cubic feet per minute per square foot at 4 inches w.g. for size 48 x 48 inches.
 - d. Pressure Drop: Maximum 0.03 inch w.g. at 1,500 feet per minute across 24 inch x 24 inch damper in a fully ducted configuration as tested per AMCA Standard 500.

2.17 OTHER EQUIPMENT REQUIREMENTS

- A. At a minimum, building level controllers and unit level controllers monitoring and/or transmitting fire alarm points shall have UL 864 UOJZ listing with Underwriters Laboratories. The controls contractor shall provide a copy of the UL certificate for their controllers.
- B. All controllers used for smoke control shall be UL 864 UUKL listed.
- C. If the DDC system is controlling a piece of equipment that is on emergency power, the DDC panel shall be connected to the same source of emergency power.
- D. All DDC primary LAN controllers, PCs and communication equipment that monitor life safety and critical points (such as fire alarm and elevator emergency) shall be connected to emergency power and have an online UPS with full-load rectification and inversion (double conversion). If a generator supports the electrical circuit, then four-hour UPS is required. If a generator does not support the electrical circuit, then 24-hour UPS is

required. The University must approve any deviations from this requirement in writing prior to bidding.

- E. Operating system for the building level network controller shall be Windows XP Professional or the most recent release of Windows.

2.18 HVAC CONTROL HARDWARE IDENTIFICATION

- A. Automatic Control Valve Tags
 1. Use metal tags with a 2-inch minimum diameter, fabricated of brass, stainless steel, or aluminum. Attach the tags with a chain of the same material.
 2. For lubrication instructions, use linen or a heavy duty shipping tag.
 3. Tag the valves with identifying number and system.
 4. Prepare a list of all tagged valves showing location, floor level, tag number, and use. Organize the list by system. Include copies in each maintenance manual.
- B. Wire Tags: All multi-conductor cables in all pull boxes and terminal strip cabinets shall be tagged.
- C. Conduit Tags: Provide tagging or labeling of all conduits so that it is readily observable which conduit was installed or used in implementation of this work.
- D. Panels and Control Devices
 1. Control Panels (Enclosures) shall be labeled.
 2. All sensors, controllers, and controlled devices shall also be labeled.
 3. Where physical space permits, the labels shall be made of black lamicoid sheet with white lettering. They shall be affixed to the panel or device by screws if possible or glue if screws are not feasible. If physical space does not permit the use of labels with readable text, tags shall be used.
 4. Identification on the labels or tags shall match the identification documented on the submittals/as-builts.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify existing conditions before starting work. The beginning of installation implies that the contractor accepts the existing conditions.
- B. The contractor shall thoroughly examine the project plans for control device and equipment locations, and any discrepancies, conflicts, or omissions shall be reported to the Engineer for resolution before rough-in work is started.
- C. The contractor shall inspect the site to verify that equipment is installable as shown, and any discrepancies, conflicts, or omissions shall be reported to the Engineer for resolution before rough-in work is started.
- D. The contractor shall examine the drawings and specifications and if head room or space conditions appear inadequate or if any discrepancies occur between the plans for work under this contract and the plans for the work of others, the discrepancies shall be

reported to the Engineer and the contractor shall obtain written instructions for any changes necessary to accommodate the work under this contract with the work of others.

3.2 PROTECTION

- A. The contractor shall protect against and be liable for damage to work and to material caused by the contractor's work or employees.
- B. The contractor shall be responsible for work and equipment until inspected, tested, and accepted.
- C. The contractor shall be responsible for protecting materials awaiting installation.
- D. The contractor shall close open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.3 COORDINATION

- A. Site
 - 1. The contractor shall assist in coordinating space conditions to accommodate the work of each trade where work will be installed near or will possibly interfere with work of other trades. If installation with coordination causes interference with work of other trades, the contractor shall correct conditions without extra charge.
 - a. Coordinate and schedule work with work in the same area and with work that is dependent upon other work to facilitate mutual progress.
- B. Submittals: See Part 1
- C. Test and Balance
 - 1. The contractor shall provide the Test and Balance Contractor a single set of necessary tools to interface with the control system for testing and balancing.
 - 2. The contractor shall provide a minimum of 4 hours of training on the use of the interface tools.
 - 3. The contractor shall provide a qualified technician to assist with the testing and balancing of one system controlled by a programmable controller and the first twenty terminal units.
 - 4. The Test and Balance contractor is obligated to return the interface tools undamaged and in working condition at completion of the testing and balancing.
- D. Network
 - 1. The contractor shall allocate space in each Building Controller control panel for the installation of a network switch. The size of the network switch shall be selected such that a minimum of one spare port is available at each control panel at the completion of the project.
- E. Life Safety
 - 1. Duct smoke detectors required for air handler shutdown are provided under Division 26. The contractor shall interlock the smoke detectors to the air handlers for shutdown as required by the sequence of control.

2. Smoke dampers and actuators required for duct smoke isolation are provided under Division 23. The contractor shall interlock the smoke dampers to the air handlers as required by the sequence of control.
 3. Fire and smoke dampers and actuators required for fire-rated walls are provided under Division 23. Fire and smoke damper control is provided under Division 26.
- F. Coordination with other controls specified in other sections or divisions: Other sections and/or division of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. The contractor shall coordinate his integration of these devices as follows.
1. All communication media and equipment shall be provided as specified in Section **XXXXXX**.
 2. Each supplier of a controls product is responsible for the configuration, programming, start-up and testing of that product to meet the sequence of control.
 3. The contractor shall coordinate and resolve any incompatibility issues that arise between the control products provided under this section and those provided under other sections or divisions of this specification.
 4. The contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
 5. The contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.
- G. Verify building posting requirements with the Owner, before starting work.

3.4 GENERAL WORKMANSHIP

- A. The contractor shall install equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.
- B. The contractor shall provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
- C. The contractor shall install all equipment in readily accessible locations as defined by Chapter 1, Article 100, Part A of the Nations Electrical Code (NEC).
- D. The contractor shall verify the integrity of all wiring to ensure continuity and freedom from shorts and grounds.
- E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.
- F. Penetrations for raceway, piping, sleeves, or other equipment shall be sealed in a manner consistent with existing building conditions and current building code requirements.
- G. Limit dust and dirt dispersal to lowest practicable level. Comply with governing regulations regarding environmental hazards and general dust control. Notify the

Owner's Representative of possible exposure to harmful dusts and vapors, flammable or explosive materials, and other potential hazards. See Appendix B - Dust, Contaminant and Odor Control Options. Patch to match existing adjacent materials. When identical patching materials are not available, review alternatives with Owner's Representative.

3.5 FIELD QUALITY CONTROL

- A. All work, materials, and equipment shall comply with the rules and regulations of applicable local, state, and federal codes and ordinances as identified in Part 1 of this specification.
- B. The contractor shall continually monitor the field installation for code compliance and quality of workmanship.
- C. The Contractor shall have work inspected by local and/or state authorities having jurisdiction over the work.

3.6 CONTINUITY OF EXISTING SYSTEM OPERATION

- A. The contractor shall make all reasonable efforts to mitigate the impact of this work on the operation of existing systems, building occupants, and research equipment.
- B. Notify the owner prior to commencing work that could or will disrupt the functions of any building or network systems. The contractor and owner will plan the detailed implementation of the contractor's work plan submitted with the proposal.
- C. The contractor shall make provisions to maintain adequate continuous system operation for equipment that serves critical research areas and all research animal holding areas.
- D. Where building DDC systems are used for fire alarm signaling, the contractor shall make provisions to maintain this function during construction. The fire alarm signaling can be disabled for construction during first shift if:
 - 1. Approved by the owner.
 - 2. BSAC fire system outage notification procedures are followed.
 - 3. Proper fire watch procedures are followed.
 - 4. The system is back online before the contractor leaves the jobsite each day.
- E. The contractor shall notify BSAC and the FM maintenance district prior to disrupting the operation of any existing equipment or system. Notification will also be made when the affected systems are back in operation.

3.7 EXPOSED WORK

- A. The controls contractor shall not run any conduit or wiring exposed below the finished ceiling or on any finished walls, unless approved by the Owner. The controls contractor shall be responsible for all cutting and patching required in connection with his work. The Owner shall approve all cutting and patching.

3.8 ENCLOSURES

- A. All building controllers and/or enclosures shall be clearly labeled with their device ID and IP address.
- B. Mark all DDC panels with circuit number and electrical panel number.

3.9 WIRING

- A. Licensed union electricians, experienced in this type of work shall perform all electrical work. The Contractor shall be responsible for all control wiring required for the proper installation of the system.
- B. All power, control, and interlock wiring shall comply with national, state and local electrical codes and Division 16 of this specification. Where the requirements of this section differ from those in Division 16, the requirements of this section shall take precedence.
- C. All components/devices used in wiring shall be UL/ETL approved, listed and stamped. All cable material and installation shall comply with State of Minnesota Fire Code requirements.
- D. Surge transient protection shall be incorporated in design of system to protect electrical components in field panels.
- E. Pathway/Raceway Construction
 - 1. All raceway construction shall be in accordance with the latest revision of the NEC and Division 16 requirements. The pathway shall be minimum EMT with a flexible section for connection to devices, or PVC (polyvinyl chloride) where corrosion is expected to be a problem. Pathway which has been crushed or deformed in any way shall not be installed.
 - 2. Bends of pathway system shall be made such that the pathway shall not be injured and that the internal diameter of the conduit will not be effectively reduced. The radius of the curve shall not be less than that recommended by either the NEC or manufacturer of the wires or cable to be contained within the pathway. Wherever possible, the maximum angle of bends between pulls shall not total more than 270 degrees including the entrance to and from the pull box.
 - 3. The maximum allowable distance between pull points shall be 300 feet. When the distance between the two pull points contains bends, the maximum allowable distance shall be 75 feet. A lubricating agent compatible with the wire insulation shall be used. The pull boxes shall be sized to allow for an adequate bending radius for the wire or cable being pulled.
 - 4. The combined cross-sectional area of all conductors and cables shall not exceed 40% of the total cross-sectional area of the pathway. The minimum size of pathway is $\frac{3}{4}$ inches in diameter. Pathway on equipment to end devices minimum size will be $\frac{1}{2}$ inches and no longer than 3 feet.
 - 5. Pathway shall be firmly supported within one meter or 3 feet of each pull box, junction box or termination point. The pathway shall be sufficiently supported elsewhere in accordance with NEC requirements. Pathway runs shall be solidly connected to assure the ground continuity of the entire length. Ground jumpers shall be installed where the possibility of losing continuity exists.
 - 6. Pathway runs shall be provided with condensation drains at low points. Pathway runs shall be parallel or perpendicular to building walls.
 - 7. Conduit Supports
 - a. Single runs: Galvanized conduit straps or ring bolt type hangers with specialty spring clips. Do not use plumber's perforated straps.

- b. Multiple runs: Conduit rack with 25 percent spare capacity.
 - c. Vertical runs: Channel support with conduit fittings.
 - d. Anchor Methods
 - (1) Hollow masonry: Toggle bolts or spider type expansion anchors.
 - (2) Solid masonry: Lead expansion anchors or precast inserts.
 - (3) Metal surfaces: Machine screws, bolts, or welded studs.
 - (4) Wood surfaces: Wood screws.
 - (5) Concrete surfaces: Self drilling anchors or power driver studs.
 - 8. The size of raceway and size and type of wire shall be the responsibility of the contractor, in keeping with the manufacturer's recommendations and NEC requirements, except as noted elsewhere.
 - 9. EMT and rigid conduit size shall be 3/4" or greater.
 - 10. Covers for J-Boxes used with DDC system wiring shall be painted green and/or stenciled with "DDC".
 - 11. Include one pull string in each raceway that is 1 inch in diameter or larger.
 - 12. Conceal all raceways, except within mechanical, electrical, or service rooms. Install raceway to maintain a minimum clearance of 6 inches from high-temperature equipment such as steam pipes or flues.
 - 13. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.
 - 14. Adhere to Division 16 requirement where raceway crosses building expansion joints.
 - 15. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of all vertical raceways.
 - 16. Flexible metal raceways and liquid-tight, flexible metal raceways shall not exceed 3 feet in length and shall be supported at each end. Flexible metal raceway less than 1/2 inch electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.
 - 17. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with coupling according to code. Terminations must be made with fittings at boxes and ends not terminating in boxes shall have bushings installed.
- F. Class 1 Wiring
- 1. All NEC Class 1 (line voltage) wiring shall be UL Listed in approved raceway according to NEC and Division 16 requirements.
 - 2. Maximum allowable voltage for control wiring shall be 120 Volts. If only higher voltages are available, the contractor shall provide step-down transformers.
- G. Low Voltage (Class 2) Wiring

1. Low voltage wiring shall meet NEC Class 2 requirements. Sub-fuse low voltage power circuits as required to meet Class 2 current limits. Maximum control transformer size is 100VA without prior approval from Owner.
2. Class 2 wiring installed above hard ceilings or other inaccessible locations shall be run in approved raceway.
3. All exposed Class 2 wiring shall be enclosed in metallic conduit or raceway.
4. All wiring in mechanical, electrical, or service rooms, or where subject to mechanical damage, shall be installed in raceway at levels below 10 feet.
5. Low voltage wiring installed above lay-in or other accessible ceilings shall be in conduit unless specifically allowed by the University. If allowed, open cable installations will adhere to the requirements of this section.
6. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL Listed for the intended application.
7. Install plenum wiring in sleeves where it passes through walls and floors. Maintain the fire rating at all penetrations.
8. Where Class 2 wiring is run without raceways:
 - a. Wiring is to be run parallel along a surface or perpendicular to it
 - b. Wiring will be neatly tied at 10 foot intervals or less as required to prevent excessive sagging.
 - c. Wiring shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.
9. The contractor shall not install Class 2 wiring in raceway containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g., relays and transformers).
10. The contractor shall not install wiring in raceway containing pneumatic tubing.
11. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire to wire connections shall be at a terminal block.
12. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
13. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.
14. Use coded conductors throughout with conductors of different colors.

H. Other Requirements

1. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.
2. The contractor shall terminate all control and/or interlock wiring and shall maintain updated as-built wiring diagrams with terminations identified at the job site.

3. Unless required for life safety system operation, wire all safeties so the fan shuts down even if the HOA switch is in the hand position. On a fan system with VFDs, wire the safeties so the fan shuts down if the VFD is in hand or bypass mode of operation.

3.10 COMMUNICATION WIRING

- A. The contractor shall adhere to the items listed in the previous section on WIRING.
- B. The contractor shall install all cabling in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling.
- C. The contractor shall not install communication wiring in raceway and enclosures containing Class 1 wiring.
- D. When a cable enters or exits a building, the contractor shall install a lightning arrester between the lines and ground. The lightning arrester shall be installed according to the manufacturer's instructions.
- E. The contractor shall install all runs of communication wiring with un-spliced lengths when that length is commercially available.
- F. The contractor shall label all communication wiring to indicate origination and destination data.
- G. The contractor shall ground coaxial cable in accordance with NEC regulations on "Communications Circuits, Cable, and Protector Grounding."
- H. When shielded wiring is use, the contractor shall ground the shield only once for each continuous segment of cable. The grounding location shall be at the end of the segment that is most readily accessible.

3.11 NETWORK COMMUNICATION TRUNK AND TERMINATIONS

- A. A backbone communication trunk will be provided and installed by the University of Minnesota. All network fiber shall be 62.5 micron FDDI grade. The University will provide the fiber connection in one location in the building. The controls contractor is responsible for all DDC network wiring within the building.
- B. The controls contractor shall tag all fiber or copper cable with a tag indicating "BSAC Fiber or BSAC Cable." All lower level panel-to-panel networking and fiber patch cords shall be the responsibility of the controls contractor.
- C. The controls contractor shall connect the new system to the dedicated fiber communication trunk and provide all components necessary (hubs, switches, links, modems, connectors, cables, interface equipment, software, labor, etc.) for communication on the dedicated University DDC network to the vendor's master work station. Hub and switch locations shall be supported by a four hour UPS, provided by the University, and emergency power.
- D. The controls contractor shall provide a network riser for all locations as part of construction, submittals and as-built documents. All fiber and network devices shall be clearly marked.

3.12 IP INTERFACE DEVICES

- A. Install Building Controllers for each required connection to the dedicated DDC TCP/IP network.
- B. The Building Controllers shall be configured and commissioned to ensure that the only data traffic on the TCP/IP is data that is essential for operation of the system. Messages between field devices on the same field bus shall not be allowed to pass onto the TCP/IP network.

3.13 SENSORS

- A. The contractor shall install sensors in accordance with the manufacturer's recommendations.
- B. The contractor shall mount sensors rigidly and adequately for the environment within which the sensor operates.
- C. The contractor shall install all sensors in accessible locations.
- D. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.
- E. All wires attached to sensors shall be air sealed in their raceways or in the wall to prevent air transmitted from other areas from affecting sensor readings.
- F. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
- G. Low-limit sensors used in mixing plenums shall be installed in a serpentine manner horizontally across the duct. Each bend shall be supported with a capillary clip. Provide 1 foot of sensing element for each square foot of coil area.
- H. All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in the thermal wells.
- I. Install outdoor air temperature sensors on the north wall, complete with a sun shield at the designated location.
- J. Differential air static pressure sensors:
 - 1. For supply duct static pressure, pipe the high pressure tap to a duct probe that measures at a 90 degree angle to flow (to measure only the static pressure and not the effects of velocity). Pipe the low-pressure port to the plenum.
 - 2. For return duct static pressure, pipe the low pressure tap to a duct probe that measures at a 90 degree angle to flow (to measure only the static pressure and not the effects of velocity). Pipe the high-pressure port to the plenum.
 - 3. For building static pressure, pipe the low-pressure port of the sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.
 - 4. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.

5. Mount transducers in a location accessible for service without the use of ladders or special equipment to the maximum extent possible.
- K. All water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shutoff valves installed before the tee.
- L. Annular pitot tubes shall be installed so that the total head pressure ports are set-in-line with the pipe axis upstream and the static port facing downstream. The total head pressure ports shall extend diametrically across the entire pipe. Annular pitot tubes shall not be used where the flow is pulsating or where pipe vibration exists.

3.14 FLOW SWITCHES

- A. Airflow Switches
 1. Install in horizontal duct runs whenever possible.
 2. If a vertical duct run is the only option, then install in a location with an upward airflow.
- B. Hydronic Switches
 1. Use the correct paddle type for the pipe diameter as described by the switch manufacturer.
 2. Adjust the flow switch in accordance with the manufacturer's instructions.

3.15 ACTUATORS

- A. Damper actuators shall be provided with all mounting hardware and linkages.
- B. Mount and link control damper actuators according to manufacturer's instructions.
- C. When spring return actuators are used on normally closed dampers, the seals shall be compressed when the dampers have been closed by the actuator.
- D. Damper/actuator combinations shall modulate smoothly from fully closed to fully open and return.
- E. Actuator Selection
 1. Size damper actuators to operate the related control damper(s) with sufficient reserve power to provide smooth modulating action or two-position action.
 2. Actuators shall also be sized for proper speed of response at the velocity and pressure conditions to which the control damper is subject.
 3. Shall produce sufficient torque to close off against the maximum system pressures encountered.
 4. Shall produce sufficient torque to close off against the fan shutoff pressure as a minimum.
 5. The total damper area operated by an actuator shall not exceed 80% of the manufacturer's maximum area rating. Provide at least one actuator for each damper section. Each damper actuator shall not power more than 20 square feet of damper area.
 6. Use line shafting or shaft couplings (jackshafting) in lieu of blade-to-blade linkages or shaft coupling when driving axially aligned damper sections.

- F. Electric/Electronic Damper Actuators
 - 1. Shall be direct-mounted on the damper shaft or jackshaft unless shown as a linkage installation.
 - 2. Shall be mounted following the actuator manufacturer's recommendations.
- G. Electric/Electronic Valve Actuators
 - 1. Shall be connected to the valve with adapters approved by the actuator manufacturer.
 - 2. Shall be mounted following the actuator manufacturer's recommendations.

3.16 CONTROL DAMPERS

- A. Install dampers in accordance with the manufacturer's instructions to operate and to obtain leakage rates specified herein. Adjust the damper linkage such that the damper closes before the actuator is fully closed to assure tight shut-off of the damper.
- B. Blank-off and seal around dampers and between dampers and sleeves or frames to eliminate air by-pass.
- C. For outdoor air damper assemblies, stage the opening of each section to prevent stratification and poor mixing of outside and return air.

3.17 CONTROL VALVES

- A. Install in an accessible location, with room for actuator removal and service. Adjust the actuator to provide tight shutoff. Provide valve stem indicator and adjust to indicate proper travel.
- B. Where butterfly valves are used, permanently mark the end of the valve shaft to indicate the valve position.

3.18 WARNING LABELS

- A. The contractor shall affix permanent warning labels to all equipment that can be automatically started by the DDC system.
 - 1. Labels shall use white lettering, 12 point type or larger, on a red background.
 - 2. The labels shall read: "CAUTION: This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to the OFF position before servicing."
- B. The contractor shall affix permanent warning labels to all motor starters and all control panels that are connected to multiple power sources utilizing separate disconnects.
 - 1. Labels shall use white lettering, 12 point type or larger, on a red background.
 - 2. The labels shall read: "CAUTION: This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing."

3.19 IDENTIFICATION OF HARDWARE AND WIRING

- A. The contractor shall label all wiring and cable, including that within factory-fabricated panels, at each end and within 2 inches of the end of the cable with the DDC address or termination number.
- B. The contractor shall label all pneumatic tubing at each end within 2 inches of the end with a descriptive identifier.
- C. The contractor shall label all control panels with minimum ½ inch letters on laminated plastic nameplates.
- D. The contractor shall identify all other control components with permanent labels. All plug-in components shall be labeled on both the removable component and the permanently installed base such that it is obvious where the removed component is to be re-installed.
- E. The contractor shall label room sensors relating to terminal box or valves with nameplates.
- F. Manufacturer's nameplates and UL or CSA labels are to be visible and legible after equipment is installed.
- G. All identifiers shall match the as-built documents.

3.20 PROGRAMMING FOR PROGRAMMABLE DEVICES

- A. These requirements apply to Building Controllers and Unit Level Controllers.
- B. All process control loops for an integral system shall reside in a single controller. Examples of integral systems are:
 - 1. Air handling units.
 - 2. Packaged chillers.
 - 3. Chillers, excluding pumps and tower.
 - 4. Boilers.
- C. To the maximum extent possible, all process control loops for built up systems shall reside in a single controller. An example is a chiller with its associated chilled water and condenser water pumping systems or a boiler system with steam to hot water heat exchangers. The objective of this requirement is that the contractor shall use large point count primary controllers in lieu of multiple secondary controllers.
- D. Supervisory logic for integral and built up systems may reside in building controllers with the output commands to the process control loops traversing the field bus to the controllers executing the process control.
- E. The contractor shall create and download application programs that meet the requirements of the sequence of operations, time scheduling requirements, trend logging requirements, alarm handling requirements and data visibility requirements at the OWS.
 - 1. The contractor shall use the University point naming convention throughout the project.

2. All time schedules shall be fully configured with weekly schedules and all of the holidays identified by the owner.
 3. All trend logs identified in the sequence of control shall be fully configured and operational.
 4. All alarm handling shall be consistent with University alarming standards. See Appendix B for current standards.
 5. All application parameters identified as (adj) in the sequence of control shall be exposed as viewable parameters and appropriate initial values shall be set.
 6. Manual control of all external points shall be configured with BACnet command priority eight (8) unless otherwise specified in the sequence of control.
 7. For all variables broadcast onto the field bus, event driven communication shall be used to avoid data storms. As a minimum the program shall provide for the send on delta parameter and minimum send time parameter for each output variable.
 8. The contractor shall embed into the programs sufficient comment statements to clearly describe each section of the program. This applies to both line programming and graphical programming systems.
 9. If graphical programming systems with multiple layers for the functional block diagrams are used, no more than two layers shall be used.
- F. All device-to-device (peer-to-peer) data flow shall be in place and configured to meet the sequence of control.
- G. The programmed applications for a single integrated system shall not be distributed over more than one field bus. Examples:
1. A chiller is controlled by a controller on field bus number 1. The controllers that control the pumps and tower shall also be on field bus number 1 as these systems are integrated in their control requirements.
 2. Multiple air handling units are controlled by controllers on field bus number 1. The chiller system is controlled by controllers on field bus number 2. The chiller control logic requires the chilled water valve positions from each of the air handling unit controllers. It is acceptable that these related but non-integral systems are controlled by controllers on different field busses.

3.21 SERVERS AND WORKSTATIONS

- A. The contractor shall install a data server and operator work stations as shown on the contract drawings.
- B. All required software for fully functional systems shall be installed and configured. The owner shall provide the IP connections and identify the specific rooms where the computers shall be installed.

3.22 CLEANING AND FINISHING

- A. The controls contractor shall maintain good housekeeping at all times. Keep the premises free from accumulations of waste materials or rubbish caused by execution of the work. At completion of the work the Contractor shall leave all work locations in a first class clean condition. In case of dispute, the Owner may remove the rubbish and charge the

cost to the Contractor. The controls contractor shall be responsible for removing and reinstalling any ceiling tiles necessary to perform the work. Damaged tiles will be replaced at the Contractors expense.

- B. The entire project area shall be cleaned immediately prior to final inspection.
- C. Each surface or unit shall be cleaned to the condition expected in a normal, commercial building cleaning and maintenance program.
- D. Cleaning shall include the interior of cabinets and casework, converters, unit heaters, radiation, electric panels, and similar items, and such accessible spaces as tunnels, shafts, pipe spaces, plenums, crawl spaces and similar areas.
- E. When punch-list work generates dust and debris, an additional cleaning will be needed prior to occupancy.

3.23 SYSTEMS INTEGRATION

- A. The controls contractor shall be fully responsible for the installation and commissioning of the integrated system.
- B. Controls contractor shall be responsible for all on-site and off-site programming as required to provide a fully operational integrated system. Contractor shall coordinate all programming and point mapping requirements with University personnel. If the Contractor deems changes to the Contract Documents necessary, submit details in writing, to the Owner for approval.
- C. The controls contractor shall provide all engineering and analysis work necessary to determine the method of network connectivity. The Contractor shall furnish, install and program hardware, wiring, network devices, cabling, software and graphics to connect the new DDC controls system to the University DDC network. The interface will allow, at a minimum, the following:
 - 1. Alarm annunciation in BSAC
 - 2. Output control
 - 3. Analog and digital commands
 - 4. Reset commands
 - 5. Point enable and disable
 - 6. Set point adjustments
 - 7. Time Of Day Scheduling
 - 8. Dynamic Alarm Synchronization

3.24 BUILDING SYSTEMS AUTOMATION NETWORK PERFORMANCE REQUIREMENTS

- A. The temperature controls contractor will supply all hardware software labor, material and expertise necessary to tie the BACnet building controller(s) to the University private DDC control network. BACnet integration must conform to Data Link Layer Option BACnet /IP shown in BACnet ANSI/ASHRAE 135-2004 publication Annex J.
- B. The controls contractor must install all new building level controllers such that BACnet communications on the existing temperature control network are not derogated.

Derogation includes router, switch, hub lockups, BACnet building controller lockups, site network excessive slowdowns, unnecessary and repeated 'who is' messages. Refer to ASHRAE BACnet standard for definition of unnecessary Who-is messages.

- C. All BACnet read property requests from the U of M Master BACnet Operator Workstation must not take more than 5 seconds to process once the BACnet Building Controller receives the read request. Object properties that are read requested that require multiple segmented packets must not take more than 5 seconds to process the request. All information that is received from a read property multiple or single read property must not be older than 10 seconds.

3.25 TRAINING:

- A. The Control Contractor shall schedule twenty four (24) hours of system training with a minimum of two weeks notice.
 - 1. All training must be held on-site.
 - 2. An outline of the proposed agenda shall be submitted to Energy Management for review.
 - 3. Training shall be performed during normal working hours with project personnel who are familiar with the full scope of the integration project and the vendor's front-end workstation.
 - 4. The training shall consist of instructions in the proper operation, programming, and maintenance of the selected vendors system.
 - 5. The Contractor shall instruct the Owner's personnel so that they can troubleshoot and maintain integration hardware and databases, program, reprogram, and/or reenter the desired schedules, values, settings, and strategies.

3.26 DOCUMENTATION

- A. The controls contractor shall provide three (3) bound copies of Owner's Manuals (i.e. equipment Data drawings with sequence of operations, Operational Manuals, As-built drawings, etc.)
- B. The controls contractor will include control equipment drawings for each building. Submittal drawings will include network diagrams, panel layout drawings, detailed equipment drawings, description of operation, wiring diagrams, termination details, point schedules, trunk layouts including power supplies at all bus levels, and room schedules. Drawings shall be "B" sized 11 inches x 17 inches. Submittal brochures will include detailed product data sheets on all integration devices.
- C. The controls contractor will include in the submittals a detailed point list for each integrated building. The point list shall detail the point descriptor, the type of input or output (i.e., DI, DO, AI, AO) and software points. The point list must be submitted to the Owner's Representative for review and approval.
- D. As-built drawings will each be stamped "As-Built" and have the as-built date on them. Copies of as-built drawings shall include the following at a minimum: Detailed drawings for each piece of controlled and monitored equipment, point lists, sequence of operations, hardware with part information, logic tables, room schedules, and O & M manuals. As part of the as-built drawings, the Contractor will provide a drawing that shows the detailed routing of all communication trunk wires (building-to-building and

within building), locations of all network and integration devices, front-end workstations, UPS and campus network/LAN connections.

- E. The controls contractor shall provide electronic copies of all as-built documentation to the University. The electronic copies shall be stored on CDs and shall be saved in an editable format. Acceptable formats include Microsoft Office program formats (i.e. Word, Excel, Access, etc.), Visio, and AutoCAD. Other formats must be approved by the University at time of project award.

3.27 CONTROL SYSTEM CHECKOUT

- A. The contractor shall furnish all labor and test apparatus required to execute the start up testing plan. Key tasks to be executed and documented in the start up testing report include:
1. Verification of all primary and secondary voltages.
 2. Verification that power wiring for all devices conforms to manufacturer's instructions.
 3. Verification that all labeling is in place.
 4. Inspection of wiring for loose strands and tight connections.
 5. Verification of field bus topology, grounding of shields (if used) and installation of termination devices.
 6. Verification that each I/O device is landed per the submittals and functions per the sequence of control.
 - a. Analog sensors shall be properly scaled and a value reported to the OWS.
 - b. Binary sensors shall have the specified normal position and the state is reporting properly to the OWS.
 - c. Analog outputs have the specified normal position and move full stroke when so commanded.
 - d. Binary outputs have the specified normal state and respond to energize/de-energize commands.
 7. Analog sensors calibrated with high quality instrumentation suitable for the sensor being calibrated.
 - a. The instruments shall display a current (12 month) NIST traceable calibration sticker. Associated instrument calibration certificates shall be made available within 24 hours of a request.
 - b. The measured value, reported value, and the calculated offset that was entered into the database shall be recorded.
 - c. The calibration criteria shall be:
 - (1) Space Temperature: +/- 0.5 degrees F
 - (2) Air Temperature: +/- 0.5 degrees F
 - (3) Fluid Temperature: +/- 0.5 degrees F
 - (4) Air Flow Rate: +/- 5 %
 - (5) Liquid Flow Rate: +/- 5 %
 - (6) Differential Pressure: +/- 3 %

- (7) Gauge Pressure: +/- 5%
 - (8) Relative Humidity: +/- 3 % relative humidity
 - (9) CO2: +/- 2 %
8. Loop Tuning
- a. The contractor shall tune all P, PI and PID control loops.
 - b. The loop tuning criteria shall be a stable control loop where the average error over 15 minutes and 30 samples shall be less than:
 - (1) Space Temperature: +/- 0.75 degrees F
 - (2) Air Temperature: +/- 1.50 degrees F
 - (3) Air Humidity: +/- 5 % relative humidity
 - (4) Chilled Water Temp: +/- 1.00 degrees F
 - (5) Hot Water Temp: +/- 1.00 degrees F
 - (6) Duct Pressure: +/- 0.2 inches w.g.

3.28 TESTING AND COMMISSIONING

- A. The HVAC and control systems shall be commissioned in accordance with the project Commissioning Plan. If no Commissioning Plan has been prepared, the systems shall be commissioning in accordance with ASHRAE Guideline 1-1996. The controls contractor shall provide assistance, staff and materials to support the commissioning activities.
- B. All buildings transmitting fire alarm signals will be tested in accordance with the 2002 EDITION of NFPA 72; 4.5 Documentation, 4.5.1; Approval and Acceptance, sub-section 4.5.1.2, 4.5.2; Completion Documents and 4.5.3 Records. Test transmission of fire, trouble and supervisory signals. University of Minnesota staff and Code Officials are available for consultation and testing support.
- C. The controls contractor shall provide assistance, staff and materials to support the commissioning activities in the presence of a designated University Representative, which shall include the following tests:
 - 1. When installation is complete, verify and document communication transmission between each building, the vendor's master workstation, and any third party BACnet work station. The controls contractor is responsible for all final adjustments and testing. Submit test report to the Owners Representative as part of the final operational test.
 - 2. Field test the accuracy of all points and verify that the vendor's front end and third party BACnet work station receives the change of states. Field point status must be in sync with the present alarm conditions, values, and status of points that are mapped into the third party BACnet work station. Any device out of the specified range shall be identified in the checkout report. All field controller information for analog, digital, software points, etc, received at the integrated front end, shall not be more than 10 seconds old.
 - 3. All analog inputs shall be verified for accuracy according to the specifications for the device. Any device out of the specified range shall be replaced. The devices shall be tested against the calibrated instrument used in the initial setup of the device.
 - 4. Switch the status of all digital inputs from the final field device. Verify that BSAC received the change of state.

5. The building control system shall provide commands to all outputs. Proper operation shall be verified in the field.
 6. All DDC panels shall be tested for panel alarm condition and communication trunk will be tested for panel no response alarm conditions at the vendor's master workstation and at the MLWS.
- D. All points shall be in the automatic mode when the project is turned over to the University.
- E. Verification Testing.
1. The University will perform verification tests on all equipment installed as part of this project.
 2. The University will develop verification test plans for each system.
 3. The controls contractor is responsible for providing materials and labor to assist the University with verification testing. A University representative will witness all verification testing.
 4. The University will compile a log of open and deficient items observed during the testing.
 - a. The controls contractor shall complete all required repairs, test the system, and inform the University that the open and deficient items have been resolved within one week after receipt of the log.
 - b. The University will retest the corrected items to confirm they are complete. It is expected that the controls contractor will correct all deficiencies in a timely manner and that multiple retesting by University staff will not be required.
 - c. If more than one retest on the same system is required, the University may back charge the controls contractor for all additional retests at a rate of \$100/hr per person.

3.29 SERVICE AND SPARE PARTS

- A. During the warranty period, the controls contractor shall provide service on hardware and software components with technical staff located in the Minneapolis/St. Paul Metropolitan Area.
- B. All service items and spare parts shall be available from the manufacturer or Contractor's stock for a minimum of 5 years following the expiration of the warranty period.

3.30 ALARMS

- A. Contractor shall configure alarms as required by the latest University DDC alarm guidelines in Appendix B.
- B. The completed system must be capable of transmitting all fire alarms, emergency signals and building control points from the selected vendors systems to the MLWS. A panel failure alarm must be transmitted to the third party BACnet system when a DDC controller or network fails. Alarm conditions shall be printed and stored in an electronic text format for immediate and future reference.

- C. All binary alarm points shall be Normally Open contacts (closed contact mean alarm).
- D. The controls contractor shall discuss with Energy Management the software procedures for specific types of alarm lockouts. If different limits are needed, the controls contractor shall get approval from Energy Management before programming alarm limits. The controls contractor is responsible for high and low alarm limits for analog input points. All critical digital input points shall be programmed as alarmable points. All analog and digital points for process equipment need to be reviewed with the process equipment owner or building occupant for alarm conditions.
- E. The vendor's system and integrated system shall have the capability to recognize alarm point limits and alarm point lockouts from field panels for Dynamic Alarm Synchronization. On systems that are seasonal in operation or have alarm limits controlled based on control logic, the alarm reporting will be automatically overridden when the equipment is shut off and the alarm condition shall read normal if the limits are within the alarm range.
- F. All analog temperature, pressure, and other process variables shown in the alarm guidelines that are actively controlled by the DDC system shall be configured with dynamically resetting alarm limits linked to the control setpoint. The point shall be in alarm whenever the present value of the point is away from setpoint by more than the programmable deviation limit, subject to the alarm delays shown in the guidelines. The default deviation limits for analog points are as follows:
1. Discharge Air Temperature: +/- 5⁰F
 2. Other AHU Temperatures: +/- 5⁰F
 3. Duct Static Pressure: +/- 0.2 in w.c.
 4. Room Temperature: +/- 5⁰F
 5. Space Humidity: +/- 10%
 6. Discharge Air Humidity: +/- 10%
 7. Hot Water System Temperatures: +/- 5⁰F
 8. Chilled Water System Temperatures: +/- 3⁰F
 9. Hydronic System Pressures: +/- 10% of setpoint or 1 psi whichever is greater
- G. All alarms must be routed to a BACnet notification class capable of routing BACnet alarms to a third party BACnet device. If applicable, alarmed points should be set to BACnet intrinsic. Proprietary alarming methods requiring use of vendor specific software to view alarms are prohibited. Alarmable points must be routed to the proper BSAC console operator terminal via a recipient entry into a BACnet notification class object. Routing for Console 1 operator position includes the East Bank & Northwest District and University of Minnesota – Duluth (UMD). Console 3 operator position includes the Saint Paul District & Academic Health District. All intrinsic reporting must also be routed to the BSAC Master Alarm History Recorder which is located in the B30 Donowe Building at BACnet device ID 123456. A BACnet Broadcast Management Device has been initiated on each subnet. Additional BBMD support, when needed, is the control contractor's responsibility. BBMD must fully support foreign device registration.

3.31 SOFTWARE AND GRAPHICS

- A. The controls contractor shall provide all necessary non-disclosure and license agreements for required software. Energy Management shall receive all software licenses, the original copies of all software loaded into the system, and back-ups of all system databases and programs on CDs. All original software and documentation shall be delivered to Energy Management in the Donhowe Building. During the project, the controls contractor shall maintain disk or CD copies of all data files, application programs, and system software.
- B. Two copies of all software and/or hardware needed to configure all control devices shall be provided to the Owner at the completion of the project. This includes any software tools, cabling, disks, etc. needed to program, configure, and maintain building and unit level DDC devices along with all networking hardware provided as part of the project.
- C. The controls contractor shall update all DDC controllers to the latest released version of firmware at the completion of the project. Identical controllers shall all have the same software revision number when the project is complete.
- D. The controls contractor shall make available and install DDC system and configuration software fix packs and patches at no cost to the University during the warranty period.
- E. The controls contractor shall make available and install DDC system and configuration software version upgrades released during the warranty period at no cost to the University.
- F. When the controls contractor integrates the selected vendors system into the vendor's master workstation or third party BACnet system, all workstations shall be updated with the new system software, databases, graphics, etc.
- G. In coordination with the requirements, specifications, and existing operating conditions the controls contractor shall program all schedules, parameters, high/low limits, control strategies, alarm values, descriptor, engineering units, map all physical and software points into the vendor's DDC panels/work-stations or third party BACnet system for a complete operational system.
- H. The DDC operator interface shall include all software programming required to add the new building DDC databases and graphics to the existing DDC network in the Donhowe Building. The programmer for the DDC system shall map all physical and software points necessary for the operator to monitor and command all physical points and adjust all set points from the operator's PC without requiring any additional program modifications. The controls contractor shall verify and remove all points from the database that are not used in the program. The controls contractor also shall be responsible for all point mapping and input/output object creation. A minimum of eight points shall be mapped from all VAV controllers to the vendor's master workstation and/or integrated system.
- I. The addition of the vendors DDC points to the new subsystem shall not cause that subsystem or any other subsystem to stop functioning (crash) or slow down the request for point information. Subsystem start up synchronization between field panels and or vendor workstations and any subsystem shall not cause that subsystem or any other subsystem to stop functioning (crash) or slow down the request for point information.

- J. All database programs shall be compiled and/or de-compiled for errors before saving to the master front-end hard drive. Follow the specific procedures for directory, path and file names.
- K. The controls contractor shall upload all DDC controller databases, including network controller level DDC programs, to the vendors master workstation front end PC located in BSAC. Primary and secondary bus controllers, including VAV box controllers, shall be uploaded and saved separately to the vendor's master workstation.
- L. The University shall have the capability to add, modify and delete time of day schedules, holiday schedules, weekday schedules, weekend schedules, temporary schedules, etc. from the vendor's front end.

3.32 GRAPHIC STANDARDS FOR BUILDING SYSTEMS

- A. Graphics shall be generated from the vendor's template library. New graphics shall be created at the vendor's workstation. System graphics shall be developed for the vendors DDC system or at the integrated operator's workstations, not both. Discuss graphic development as part of the bid and design process. Vendor's workstation graphics shall follow all existing U of M graphic standards including 'Fan Served Area served and 'Quick Reference' text table sections. The University will provide the 'Fan Served Area' in Auto-Cad version 14.
 - 1. All hardware points shall have graphic(s) assigned
 - 2. All user adjustable software points shall have graphic(s) assigned
 - 3. Starting graphic for University campus with zones 1 through 5.
 - 4. Each new building shall belong to one of the five zones.
 - 5. Create graphic for outside conditions (Outside air, humidity, enthalpy, etc.)
 - 6. The graphics shall note the analog output range and normal position.
- B. Each piece of equipment shall have one or more graphics to include the following:
 - 1. All hardware points
 - 2. All user adjustable set points
 - 3. All safety alarm points for the system (Fan, pump, static, freezestat, etc)
 - 4. Heating/cooling switchover points
 - 5. Occupancy/unoccupancy points
 - 6. Summer/Winter mode points
 - 7. Create graphic(s) for fire systems and other life and safety system alarms (Fire system, carbon monoxide, oxygen depletion, etc).
 - 8. Create graphic(s) for all other critical points (Elevator, control air, phase outage, generator, city water, etc.).
 - 9. Create graphic for steam points (Steam pressures, flow meters, etc.).
 - 10. Create separate graphic(s) when more than 5 identical type of alarm points are monitored (Six cold rooms, ten incubators, etc.).
 - 11. Create miscellaneous graphic(s) for other non-critical points (roof drain, sump pump, etc.).

12. Create graphic(s) for building layout and network system configuration with identifying the bus layout.
 13. Verify that all programmed points on each graphic are referencing the correct software/hardware point at the controller level.
- C. Other graphic criteria:
1. All graphics systems shall use standard templates and colors.
 2. Type of font and font sizes shall be identical when appropriate.
 3. All text and controller points shall be aligned properly.
 4. All points shall flash red when points are in alarm condition.
 5. When screens have minimal information, maximize the usage of the screen by enlarging the graphic.
 6. Use building equipment numbers when possible for all equipment.
 7. Points and descriptors shall not overlap.

3.33 POINT NAMING/POINT LOGICAL GROUPING AND GRAPHICS

- A. The programmer shall meet with Energy Management personnel before proceeding with programming to review point naming, system layout, point logical grouping, graphics, graphical display response time, and tree structure. The controls contractor shall contact Energy Management personnel before deviating from University Standards. Failure to work within the University Standards may result in the on Contractor being required to redo their work without being compensated
- B. Supervisory controllers must be named with their corresponding building number & panel number. Before database generation is started, controls contractors are advised to contact Energy Management for questions regarding naming. Energy Management reserves the right to require changes to point naming if the controls contractor does not clarify naming before start of the controller database(s).
- C. BACnet Object Identification numbers must also include building number and panel number. Controls contractors must coordinate Object IDs & IP address information with Energy Management prior to the start of database generation.

APPENDIX A: U of M BACnet Object Support Requirements

Controls contractor shall complete and return Appendix A with their proposal. Controls contractors must indicate Readable, Writable or Not Supported under *Proposed Temperature Control Panel Conformance* column below for all object standards shown.

Standards Required Column Definition:

Optional: Indicates that the property is optional and is not required by U of M BSAC

Readable: Indicates that the property is required by the University to be present and readable using BACnet services. This property will be read by the BSAC Master Operator Workstation.

Writable: Indicates that the property is required by the University to be present, readable, and writable using BACnet services. This property will be read from and written to by the BSAC Master Operator Workstation.

Not Req: Indicates that the property is not required by the University to be present

Alarm and Event Services:

BACnet intrinsic to device alarming method is required by U of M BSAC. All standard object properties and services that are required by ANSI/ASHRAE BACnet Standard 135-2004 for use with intrinsic reporting are required by U of M BSAC. Standard U of M required objects that support intrinsic reporting:

If Present_Value changes to a new state for longer than Time_Delay AND the new transition is enabled in Event_Enable an intrinsic alarm shall be sent for the following standard BACnet objects:

- Binary Input
- Binary Value
- Multi-state Input
- Multi-state Value

If Present_Value exceeds range between High_Limit and Low_Limit for longer than Time_Delay AND the new transition is enabled in Event_Enable and Limit_Enable an intrinsic alarm shall be sent for the following standard BACnet objects:

- Analog Input
- Analog Output
- Analog Value

If Present_Value returns within the High_Limit - Deadband to Low_Limit + Deadband range for longer than Time_Delay AND the new transition is enabled in Event_Enable and Limit_Enable an intrinsic return to normal shall be sent for the following standard BACnet objects:

- Analog Input
- Analog Output
- Analog Value

If Present_Value differs from Feedback_Value for longer than Time_Delay AND the new transition is enabled in Event_Enable an intrinsic alarm shall be sent for the following standard BACnet objects:

BACnet standard object type	Binary Output
BACnet standard object type	Multi-state Output

All BACnet Object definitions are standard types as defined by the ANSI/ASHRAE BACnet Standard 135-2004. Custom or nonstandard BACnet objects supported by the Vendor must support the

Object_Identifier, Object_Name and Object_Type properties as required by ASHRAE 135-2004. All Object properties required by ASHRAE for intrinsic reporting are required by U of M. If a standard BACnet object is not listed in this construction standard then it is not required. U of M requires support for 13 of the 23 ASHRAE 135-2004 standard objects. The U of M requires Confirmed Event Notification Service. All alarms sent to the U of M Master Operator Console Workstation and Master Alarm History PC via Notification Class Object recipient list must be set to 'Confirmed'.

The U of M requires foreign device registration support at control contractors BACnet Broadcast Management Device (BBMD). The control contractor must support BBMD capabilities for each individual subnet.

Controls contractors that are unable to comply with BACnet schedule Object:

If the controls contractor does not support the required schedule object including associated properties and services then the controls contractor will be required to submit a technical document that includes the following:

- A. Custom and proprietary schedule objects and properties which will include complete datatype and ANSI data definitions. Controls contractor will be required submit, during the job submittal phase, all information that is necessary to properly read and write schedule data into controls contractor proprietary schedule at a building panel level.
- B. Submitted proprietary schedule object data must include:
 - Internal schedule ID, name, and description information
 - Date range information when schedule is active (only if vendor supports this function)
 - Weekly schedule information
 - Holiday schedule information
 - Exception or temporary schedule information that would take precedence over normal day's behavior
 - List of references including points information that are connected to the schedule
 - Command priority for writing schedules information

Analog Input Property Identifier	Analog Input Property Datatype	Standards Required	Proposed Temperature Control Panel Conformance
Object_Identifier	BACnetObjectIdentifier	Readable	
Object_Name	CharacterString	Readable	
Object_Type	BACnetObjectType	Readable	
Present_Value	REAL	Readable-1	
Description	CharacterString	Not Req	
Device_Type	CharacterString	Not Req	
Status_Flags	BACnetStatusFlags	Readable	
Event_State	BACnetEventState	Readable	
Reliability	BACnetReliability	Not Req	
Out_Of_Service	BOOLEAN	Readable	
Update_Interval	Unsigned	Not Req	
Units	BACnetEngineeringUnit	Readable	
Min_Pres_Value	REAL	Not Req	
Max_Pres_Value	REAL	Not Req	
Resolution	REAL	Not Req	
COV_Increment	REAL	Optional-2	
Time_Delay	Unsigned	Optional-3	
Notification_Class	Unsigned	Optional-3	
High_Limit	REAL	Optional-3	
Low_Limit	REAL	Optional-3	
Deadband	REAL	Optional-3	
Limit_Enable	BACnetLimitEnable	Optional-3	
Event_Enable	BACnetEventTransitionBits	Optional-3	
Acked_Transitions	BACnetEventTransitionBits	Optional-3	
Notify_Type	BACnetNotifyType	Optional-3	
Event_Time_Stamps	BACnetARRAY[3]of BACnetTimeStamp	Optional-3	
Proile_Name	CharacterString	Not Req	

1 This property is required to be writable when Out_Of_Service is TRUE.

2 This property is required if the object supports COV reporting. (Not Required by the U of M)

3 These properties are required if the object supports intrinsic reporting. (Required by the U of M)

Analog Output Property Identifier	Analog Output Property Datatype	Standards Required	Proposed Temperature Control Panel Conformance
Object_Identifier	BACnetObjectIdentifier	Readable	
Object_Name	CharacterString	Readable	
Object_Type	BACnetObjectType	Readable	
Present_Value	REAL	Writable	
Description	CharacterString	Not Req	
Device_Type	CharacterString	Not Req	
Status_Flags	BACnetStatusFlags	Readable	
Event_State	BACnetEventState	Readable	
Reliability	BACnetReliability	Not Req	
Out_Of_Service	BOOLEAN	Readable	
Units	BACnetEngineering Units	Readable	
Min_Pres_Value	REAL	Not Req	
Max_Pres_Value	REAL	Not Req	
Resolution	REAL	Not Req	
Priority_Array	BACnet Priority Array	Readable	
Relinquish_Default	REAL	Readable	
COV_Increment	REAL	Optional-1	
Time_Delay	Unsigned	Optional-2	
Notification_Class	Unsigned	Optional-2	
High_Limit	REAL	Optional-2	
Low_Limit	REAL	Optional-2	
Deadband	REAL	Optional-2	
Limit_Enable	BACnetLimitEnable	Optional-2	
Event_Enable	BACnetEventTransitionBits	Optional-2	
Acked_Transitions	BACnetEventTransitionBits	Optional-2	
Notify_Type	BACnetNotifyType	Optional-2	
Event_Time_Stamps	BACnetARRAY[3]of BACnetTimeStamp	Optional-2	
Profile_Name	CharacterString	Not Req	

1 This property is required if the object supports COV reporting. (Not Required by the U of M)
2 These properties are required if the object supports intrinsic reporting. (Required by the U of M)

Analog Value Property Identifier	Analog Value Property Datatype	Standards Required	Proposed Temperature Control Panel Conformance
Object_Identifier	BACnetObjectIdentifier	Readable	
Object_Name	CharacterString	Readable	
Object_Type	BACnetObjectType	Readable	
Present_Value	REAL	Readable-4	
Description	CharacterString	Not Req	
Status_Flags	BACnetStatusFlags	Readable	
Event_State	BACnetEventState	Readable	
Reliability	BACnetReliability	Not Req	
Out_Of_Service	BOOLEAN	Readable	
Units	BACnetEngineering Units	Readable	
Priority Array	BACnet Priority Array	Optional-1	
Relinquish Default	REAL	Optional-1	
COV_Increment	REAL	Optional-2	
Time_Delay	Unsigned	Optional-3	
Notification_Class	Unsigned	Optional-3	
High_Limit	REAL	Optional-3	
Low_Limit	REAL	Optional-3	
Deadband	REAL	Optional-3	
Limit_Enable	BACnetLimitEnable	Optional-3	
Event_Enable	BACnetEvent TransitionBits	Optional-3	
Acked_Transitions	BACnetEventTransitionBits	Optional-3	
Notify_Type	BACnetNotifyType	Optional-3	
Event_Time_Stamps	BACnetARRAY[3]of BACnetTimeStamp	Optional-3	
Profile_Name	CharacterString	Not Req	

1 If Present_Value is commandable, then both of these properties shall be present.

2 This property is required if the object supports COV reporting. (Not Required by the U of M)

3 These properties are required if the object supports intrinsic reporting. (Required by the U of M)

4 If Present_Value is commandable, then it is required to be writable. This property is required to be writable when Out_Of_Service is TRUE.

Binary Input Property Identifier	Binary Input Property Datatype	Standards Required	Proposed Temperature Control Panel Conformance
Object_Identifier	BACnetObject Identifier	Readable	
Object_Name	CharacterString	Readable	
Object_Type	BACnetObject Type	Readable	
Present_Value	REAL	Readable-1	
Description	CharacterString	Not Req	
Device_Type	CharacterString	Not Req	
Status_Flags	BACnetStatusFlags	Readable	
Event_State	BACnetEventState	Readable	
Reliability	BACnetReliability	Not Req	
Out_Of_Service	BOOLEAN	Readable	
Polarity	BACnet Polarity	Readable	
Inactive_Text	Character String	Optional-2	
Active_Text	Character String	Optional-2	
Change_Of_State_Time	BACnetDateTime	Optional-3	
Change_Of_State_Count	Unsigned	Optional-3	
Time_Of_State_Count_Reset	BACnetDateTime	Optional-3	
Elapsed_Active_Time	Unsigned 32	Optional-4	
Time_Of_Active_Time_Reset	BACnetDateTime	Optional-4	
Time_Delay	Unsigned	Optional-5	
Notification_Class	Unsigned	Optional-5	
Alarm_Value	BACnetBinary PV	Optional-5	
Event_Enable	BACnet Event TransitionBits	Optional-5	
Acked_Transitions	BACnetEventTransitionBits	Optional-5	
Notify_Type	BACnet NotifyType	Optional-5	
Event_Time_Stamps	BACnetARRAY (3) of BACnetTime Stamp	Optional-5	
Profile_Name	CharacterString	Not Req	

1 This property is required to be writable when Out_Of_Service is TRUE.

2 If one of the optional properties Inactive_Text or Active_Text is present, then both of these properties shall be present.

3 If one of the optional properties Change_Of_State_Time, Change_Of_State_Count, or Time_Of_State_Count_Reset is present, then all of these properties shall be present.

4 If one of the optional properties Elapsed_Active_Time or Time_Of_Active_Time_Reset is present, then both of these properties shall be present.

5 These properties are required if the object supports intrinsic reporting. (Required by the U of M)

Binary Output Property Identifier	Binary Output Property Datatype	Standards Required	Proposed Temperature Control Panel Conformance
Object_Identifier	BACnetObject Identifier	Readable	
Object_Name	CharacterString	Readable	
Object_Type	BACnetObjectType	Readable	
Present_Value	REAL	Writable	
Description	CharacterString	Not Req	
Device_Type	CharacterString	Not Req	
Status_Flags	BACnetStatusFlags	Readable	
Event_State	BACnetEventState	Readable	
Reliability	BACnetReliability	Not Req	
Out_Of_Service	BOOLEAN	Readable	
Polarity	BACnet Polarity	Readable	
Inactive_Text	Character String	Optional-1	
Active_Text	CharacterString	Optional-1	
Change_Of_State_Time	BACnetDateTime	Optional-2	
Change_Of_State_Count	Unsigned	Optional-2	
Time_Of_State_Count_Reset	BACnetDateTime	Optional-2	
Elapsed_Active_Time	Unsigned 32	Optional-3	
Time_Of_Active_Time_Reset	BACnetDateTime	Optional-3	
Minimum_Off_Time	Unsigned 32	Not Req	
Minimum_On_Time	Unsigned 32	Not Req	
Priority_Array	BACnetPriorityArray	Readable	
Relinquish_Default	BACnetBinaryPV	Readable	
Time_Delay	Unsigned	Optional-4	
Notification_Class	Unsigned	Optional-4	
Feedback_Value	BACnetBinaryPV	Optional-4	
Event_Enable	BACnetEvent TransitionBits	Optional-4	
Acked_Transitions	BACnetEvent TransitionBits	Optional-4	
Notify_Type	BACnetNotifyType	Optional-4	
Event_Time_Stamps	BACnetARRAY(3)of BACnetTimeStamp	Optional-4	
Profile_Name	CharacterString	Not Req	

1 If one of the optional properties Inactive_Text or Active_Text is present, then both of these properties shall be present.

2 If one of the optional properties Change_Of_State_Time, Change_Of_State_Count, or Time_Of_State_Count_Reset is present then all of these properties shall be present.

3 If one of the optional properties Elapsed_Active_Time or Time_Of_Active_Time_Reset is present, then both of these properties shall be present.

4 These properties are required if the object supports intrinsic reporting. (Required by the U of M)

Binary Value Property Identifier	Binary Value Property Datatype	Standards Required	Proposed Temperature Control Panel Conformance
Object_Identifier	BACnetObject Identifier	Readable	
Object_Name	CharacterString	Readable	
Object_Type	BACnetObjectType	Readable	
Present_Value	REAL	Readable-1	
Description	CharacterString	Not Req	
Status Flags	BACnetStatusFlags	Readable	
Event_State	BACnetEventState	Readable	
Reliability	BACnetReliability	Not Req	
Out_Of_Service	BOOLEAN	Readable	
Inactive_Text	CharacterString	Optional-2	
Active_Text	CharacterString	Optional-2	
Change_Of_State_Time	BACnetDateTime	Optional-3	
Change_Of_State_Count	Unsigned 32	Optional-3	
Time_Of_State_Count_Reset	BACnetDateTime	Optional-3	
Elapsed_Active_Time	Unsigned 32	Optional-4	
Time_Of_Active_Time_Reset	BACnetDateTime	Optional-4	
Minimum_Off_Time	Unsigned 32	Not Req	
Minimum_On_Time	Unsigned 32	Not Req	
Priority_Array	BACnetPriorityArray	Optional-5	
Relinquish_Default	BACnetBinaryPV	Optional-5	
Time_Delay	Unsigned	Optional-6	
Notification_Class	Unsigned	Optional-6	
Alarm_Value	BACnetBinaryPB	Optional-6	
Event_Enable	BACnetEvent TransitionBits	Optional-6	
Acked_Transitions	BACnetEventTransitionBits	Optional-6	
Notify_Type	BACnetNotifyType	Optional-6	
Event_Time_Stamps	BACnetARRAY[3]of BACnetTimeStamp	Optional-6	
Profile_Name	CharacterString	Not Req	

1 If Present_Value is commandable, then it is required to be writable. This property is required to be writable when Out_Of_Service is TRUE.

2 If one of the optional properties Inactive_Text or Active_Text is present, then both of these properties shall be present.

3 If one of the optional properties Change_Of_State_Time, Change_Of_State_Count, or Time_Of_State_Count_Reset is present, then all of these properties shall be present.

4 If one of the optional properties Elapsed_Active_Time or Time_Of_Active_Time_Reset is present, then both of these properties shall be present.

5 If present_Value is commandable, then both of these properties shall be present.

6 These properties are required if the object supports intrinsic reporting. (Required by the U of M)

Calendar Property Identifier	Calendar Property Datatype	Standards Required	Proposed Temperature Control Panel Conformance
Object_Identifier	BACnetObjectIdentifier	Readable	
Object_Name	CharacterString	Readable	
Object_Type	BACnetObjectType	Readable	
Description	CharacterString	Not Req	
Present_Value	BOOLEAN	Readable	
Date List	List of BACnetCalendarEntry	Readable	
Profile_Name	CharacterString	Not Req	

Device Property Identifier	Device Property Datatype	Standards Required	Proposed Temperature Control Panel Conformance
Object_Identifier	BACnetObjectIdentifier	Readable	
Object_Name	CharacterString	Readable	
Object_Type	BACnetObjectType	Readable	
System_Status	BACnetDeviceStatus	Readable	
Vendor_Name	CharacterString	Readable	
Vendor_Identifier	Unsigned 16	Readable	
Model Name	CharacterString	Readable	
Firmware_Revision	CharacterString	Readable	
Application_Software_Version	CharacterString	Readable	
Location	CharacterString	Not Req	
Description	CharacterString	Not Req	
Protocol_Version	Unsigned	Readable	
Protocol_Revision	Unsigned	Readable	
Protocol_Services_Supported	BACnetServicesSupported	Readable	
Protocol_Object_Types_Supported	BACnetObjectTypesSupported	Readable	
Object_List	BACnetARRAY (N) of BACnet ObjectIdentifier	Readable	
Max_APDU_Length_Accepted	Unsigned	Readable	
Segmentation_Supported	BACnet Segmentation	Readable	
Max_Segments_Accepted	Unsigned	Optional-1	
VT_Classes_Supported	List of BACnet VTClass	Optional-2	
Active_VT_Sessions	List of BACnetVTSession	Optional-2	
Local_Time	Time	Optional-3,4	
Local_Date	Date	Optional-3,4	
UTC_Offset	INTEGER	Optional-4	
Daylight_Savings_Status	BOOLEAN	Optional-4	
APDU_Segment_Timeout	Unsigned	Optional-1	
APDU_Timeout	Unsigned	Readable	
Number_Of_APDU_Retries	Unsigned	Readable	
List_Of_Session_Keys	List of BACnetSessionKey	Not Req	
Time_Synchronization_Recipients	List of BACnetRecipient	Optional-5	
Max_Master	Unsigned (1..127)	Optional-6	
Max_Info_Frames	Unsigned	Optional-6	
Device_Address_Binding	List of BACnetAddressBinding	Readable	
Database_Revision	Unsigned	Readable	
Configuration_Files	BACnetARRAY (N) of BACnet Object Identifier	Optional-7	
Last_Restore_Time	BACnetDateTime	Optional-7	
Backup_Failure_Timeout	Unsigned 16	Optional-8	
Active_COV_Subscriptions	List of BACnetCOVSubscriptions	Optional-9	
Profile_Name	CharacterString	Not Req	

1 Required if segmentation of any kind is supported.

- 2 If one of the properties VT_Classes_Supported or Active_VT_Sessions is present, then both of these properties shall be present. Both properties are required if support for VT Services is indicated in the PICS.
- 3 If the device supports the execution of the TimeSynchronization service, then these properties shall be present.
- 4 If the device supports the execution of the UTCTimeSynchronization service, then these properties shall be present.
- 5 Required if PICS indicates that this device is a Time Master. If present, this property shall be writable.
- 6 These properties are required if the device is an MS/TP master node. (The U of M allows MS/TP at the building subLAN only)
- 7 These properties are required if the device supports the backup and restore procedures.
- 8 This property must be present and writable if the device supports the backup and restore procedures
- 9 This property is required if the device supports execution of either the SubscribeCOV or SubscribeCOV Property service.

Multi-state Input Property Identifier	Multi-state Input Property Datatype	Standards Required	Proposed Temperature Control Panel Conformance
Object_Identifier	BACnetObjectIdentifier	Readable	
Object_Name	CharacterString	Readable	
Object_Type	BACnetObjectType	Readable	
Present_Value	Unsigned	Readable-1	
Description	CharacterString	Not Req	
Device_Type	CharacterString	Not Req	
Status_Flags	BACnetStatusFlags	Readable	
Event_State	BACnetEventState	Readable	
Reliability	BACnetReliability	Optional-2	
Out_Of_Service	BOOLEAN	Readable	
Number_Of_States	Unsigned	Readable	
State_Text	BACnetARRAY(N) of CharacterString	Not Req	
Time_Delay	Unsigned	Optional-3	
Notification_Class	Unsigned	Optional-3	
Alarm_Values	List of Unsigned	Optional-3	
Fault_Values	List of Unsigned	Optional-3	
Event_Enable	BACnetEventTransitionBits	Optional-3	
Acked_Transitions	BACnetEventTransitionBits	Optional-3	
Notify_Type	BACnetNotifyType	Optional-3	
Event_Time_Stamps	BACnetARRAY(3) of BACnetTimeStamp	Optional-3	
Profile_Name	CharacterString	Not Req	

1 This property is required to be writable when Out_Of_Service is TRUE.

2 This property shall be required if Fault_Values is present.

3 These properties are required if the object supports intrinsic reporting (Required by the U of M)

Multi-state Output Property Identifier	Multi-state Output Property Datatype	Standards Required	Proposed Temperature Control Panel Conformance
Object_Identifier	BACnetObjectIdentifier	Readable	
Object_Name	CharacterString	Readable	
Object_Type	BACnetObjectType	Readable	
Present_Value	Unsigned	Writable	
Description	CharacterString	Not Req	
Device_Type	CharacterString	Not Req	
Status_Flags	BACnetStatusFlags	Readable	
Event_State	BACnetEventState	Readable	
Reliability	BACnetReliability	Not Req	
Out_Of_Service	BOOLEAN	Readable	
Number_Of_States	Unsigned	Readable	
State_Text	BACnetARRAY(N) of CharacterString	Not Req	
Priority_Array	BACnetPriorityArray	Readable	
Relinquish_Default	Unsigned	Readable	
Time_Delay	Unsigned	Optional-1	
Notification_Class	Unsigned	Optional-1	
Feedback_Value	Unsigned	Optional-1	
Event_Enable	BACnetEventTransitionBits	Optional-1	
Acked_Transitions	BACnetEventTransitionBits	Optional-1	
Notify_Type	BACnetNotifyType	Optional-1	
Event_Time_Stamps	BACnetARRAY(3) of BACnetTimeStamp	Optional-1	
Profile_Name	CharacterString	Not Req	

1 These properties are required if the object supports intrinsic reporting. (Required by the U of M)

Multi-state Value Property Identifier	Multi-state Value Property Datatype	Standards Required	Proposed Temperature Control Panel Conformance
Object_Identifier	BACnetObjectIdentifier	Readable	
Object_Name	CharacterString	Readable	
Object_Type	BACnetObjectType	Readable	
Present_Value	Unsigned	Readable-1	
Description	CharacterString	Not Req	
Status_Flags	BACnetStatusFlags	Readable	
Event_State	BACnetEventState	Readable	
Reliability	BACnetReliability	Optional-2	
Out_Of_Service	BOOLEAN	Readable	
Number_Of_States	Unsigned	Readable	
State_Text	BACnetARRAY(N) of CharacterString	Not Req	
Priority_Array	BACnetPriorityArray	Optional-3	
Relinquish_Default	Unsigned	Optional-3	
Time_Delay	Unsigned	Optional-4	
Notification_Class	Unsigned	Optional-4	
Alarm_Values	List of Unsigned	Optional-4	
Fault_Values	List of Unsigned	Optional-4	
Event_Enable	BACnetEventTransitionBits	Optional-4	
Acked_Transitions	BACnetEventTransitionBits	Optional-4	
Notify_Type	BACnetNotifyType	Optional-4	
Event_Time_Stamps	BACnetARRAY(3) of BACnetTimeStamp	Optional-4	
Profile_Name	CharacterString	Not Req	

1 If Present_Value is commandable, then it is required to also be writable. This property is required to be writable when Out_Of_Service is TRUE.

2 This property shall be required if Fault_Values is present

3 If Present_Value is commandable, then both of these properties shall be present.

4 These properties are required if the object supports intrinsic reporting. (Required by the U of M)

Notification Class Property Identifier	Notification Class Property Datatype	Standards Required	Proposed Temperature Control Panel Conformance
Object_Identifier	BACnetObjectIdentifier	Readable	
Object_Name	CharacterString	Readable	
Object_Type	BACnetObjectType	Readable	
Description	CharacterString	Not Req	
Notification_Class	Unsigned	Readable	
Priority	BACnetARRAY(3)of Unsigned	Readable	
Ack_Required	BACnetEventTransitionBits	Readable	
Recipient List	List of BACnetDestination	Readable	
Profile Name	CharacterString	Not Req	

Schedule Property Identifier	Schedule Property Datatype	Standards Required	Proposed Temperature Control Panel Conformance
Object_Identifier	BACnetObjectIdentifier	Readable	
Object_Name	CharacterString	Readable	
Object_Type	BACnetObjectType	Readable	
Present_Value	Any	Readable	
Description	CharacterString	Not Req	
Effective_Period	BACnetDateRange	Writable-1	
Weekly_Schedule	BACnetARRAY(7)of BACnetDailySchedule	Writable-1	
Exception_Schedule	BACnetARRAY(N)of BACnetSpecialEvent	Writable-1	
List_Of_Object_Property_References	List of BACnetDeviceObjectPropertyReference	Readable	
Priority_For_Writing	Unsigned (1..16)	Readable	
Profile_Name	CharacterString	Not Req	

1- Writable indicates a requirement of the U of M which is over and above BACnet conformance requirements.

Trend Property Identifier	Trend Property Datatype	Standards Required	Proposed Temperature Control Panel Conformance
Object_Identifier	BACnetObjectIdentifier	Readable	
Object_Name	CharacterString	Readable	
Object_Type	BACnetObjectType	Readable	
Description	CharacterString	Not Req	
Log_Enable	BOOLEAN	Writable	
Start_Time	BACnetDateTime	Optional-1,2	
Stop_Time	BACnetDateTime	Optional-1,2	
Log_DeviceObjectProperty	BACnetDeviceObjectPropertyReference	Optional-1	
Log_Interval	Unsigned	Optional-1,2	
COV_Resubscription_Interval	Unsigned	Not Req	
Client_COV_Increment	BACnetClientCOV	Not Req	
Stop_When_Full	BOOLEAN	Readable	
Buffer_Size	Unsigned32	Readable	
Log_Buffer	List of BACnetLogRecord	Readable	
Record_Count	Unsigned32	Writable	
Total_Record_Count	Unsigned32	Readable	
Notification_Threshold	Unsigned32	Optional-3	
Records_Since_Notification	Unsigned32	Readable-3	
Last_Notify_Record	Unsigned32	Readable-3	
Event_State	BACnetEventState	Readable	
Notification_Class	Unsigned	Readable-3	
Event_Enable	BACnetEventTransitionBits	Readable-3	
Acked_Transitions	BACnetEventTransitionBits	Readable-3	
Notify_Type	BACnetNotifyType	Readable-3	
Event_Time_Stamps	BACnetARRAY[3] of BACnetTimeStamp	Readable-3	
Profile_Name	CharacterString	Not Req	

1 These properties are required to be present if the monitored property is a BACnet property.

2 If present, these properties are required to be writable.

3 These properties are required if the object supports intrinsic reporting. (Required by U of M)

U of M Minimum Protocol Implementation Conformance (PIC) for BACnet Building Controller

This PIC is used to describe what parts of the BACnet standard need to be implemented at U of M in order to achieve interoperability. It is the intention of the U of M to require temperature control products to conform to select BACnet standards in order to utilize a single Master Operator Workstation.

BACnet Protocol Implementation Conformance Statement

Date: April 1st 2005

BACnet Standardized Device Profile (Annex L):

All proposed devices show must meet all U of M BACnet requirements:

- BACnet Building Controller (B-BC)**
- BACnet Advanced Application Controller (B-AAC)**
- BACnet Application Specific Controller (B-ASC)**
- BACnet Smart Sensor (B-SS)**
- BACnet Smart Actuator (B-SA)**

BACnet Interoperability Building Blocks Supported (Annex K):

Segmentation Capability:

Segmented requests supported

The U of M does not require segmentation capability. Some vendors use this for larger messages. If the vendor segments requests then it must conform to the BACnet standard.

Segmented responses supported window Size

Varies depending on usage. Not stipulated by the U of M.

Standard Object Types Supported:

The U of M will require support for the following Standard ANSI/ASHRAE 135-2004 BACnet objects. See the object tables above for Individual Object property requirements.

BACnet Object 2004 Standard	
Analog Input	Vendor required to support object
Analog Output	Vendor required to support object
Analog Value	Vendor required to support object
Average	Not required
Binary Input	Vendor required to support object
Binary Output	Vendor required to support object
Binary Value	Vendor required to support object
Calendar	Vendor required to support object
Command	Not required
Device	Vendor required to support object
Event Enrollment	Vendor required to support object for command failure
File	Not required
Group	Not required
Life Safety Point	Not required
Life Safety Zone	Not required
Loop	Not required
Multistate Input	Vendor required to support object
Multistate Output	Vendor required to support object

BACnet Object 2004 Standard	
Multistate Value	Vendor required to support object
Notification Class	Vendor required to support object
Program	Not required
Schedule	Vendor required to support object
Trend Log	Vendor required to support object

Data Link Layer Options:

X BACnet IP, (Annex J)

- BACnet IP, (Annex J), Foreign Device
- ISO 8802-3, Ethernet (Clause 7)
- ANSI/ATA 878.1, 2.5 Mb. ARCNET (Clause 8)
- ANSI/ATA 878.1, RS-485 ARCNET (Clause 8), baud rate(s) _____
- MS/TP master (Clause 9), baud rate(s): _____
- MS/TP slave (Clause 9), baud rate(s): _____
- Point-To-Point, EIA 232 (Clause 10), baud rate(s): _____
- Point-To-Point, modem, (Clause 10), baud rate(s): _____
- LonTalk, (Clause 11), medium: _____
- Other: _____

The U of M will utilize BACnet on the temperature control network LAN. BACnet /IP will be deemed acceptable. BACnet integration methods must conform to Data Link Layer Option BACnet/IP shown in BACnet ANSI/ASHRAE 135-2004 publication Annex J. The BACnet device must act as a full-fledged IP node, complete with its own IP address and IP protocol stack. BACnet tunneling will not be acceptable.

Networking Options:

- Router, Clause 6 - List all routing configurations, e.g., ARCNET-Ethernet, Ethernet-MS/TP, etc.
- Annex H, BACnet Tunneling Router over IP (This protocol is not acceptable for any U of M application)
- BACnet/IP Broadcast Management Device (BBMD)

BBMD support registrations by Foreign Devices? Yes No

The U of M requires Foreign Device Registration. If the BACnet Building Controller proposed by the temperature controls contractor does not support registrations by Foreign Device than the temperature controls contractor is required to supply a 3rd party device (BACnet router) or equivalent to perform this task.

BBMD (BACnet Broadcast Management Device) receives broadcast messages on one subnet and forwards them to another subnet.

The U of M requires BBMD support

Character Sets Supported:

Indicating support for multiple character sets does not imply that they can all be supported simultaneously.

- X ANSI X3.4
- IBM™/Microsoft™ DBCS
- ISO 8859-1
- ISO 10646 (UCS-2)
- ISO 10646 (UCS-4)
- JIS C 6226

The U of M requires ANSI X3.4 Support

All ANSI/ASHRA 135-2004 required standard object properties will be supported by the temperature controls contractor BACnet device(s). Standard object optional properties will be supported if they are a requirement of any object listed above. Unsolicited change-of-value notification is required. All objects and object properties will be supported so that alarms are sent from the temperature control contractors BACnet building controller without having to be solicited from the U of M Master BACnet Operators Workstation (B-OWS) or Master History PC.

APPENDIX B: University Alarm Standards

Contact Energy Management for the latest standards.

APPENDIX C: University Point Naming Conventions

Contact Energy Management for the latest point naming conventions.

APPENDIX D: DUST, CONTAMINANT AND ODOR CONTROL OPTIONS

Construction related dust, contaminants and odors can cause significant problems for University students and staff, which disrupt normal University functions. This is particularly true in research and patient areas. Dust is not merely a nuisance, but can cause sensitive individuals to become ill and can damage scientific equipment or ruin experimental data. The A/E shall select from among the following types of controls for projects to ensure that construction related dust, contaminants and odors do not migrate from the job site and disrupt normal University operations. Consult with the Owner's Representative and DEHS staff to select reasonable dust control measures that fit the situation.

If construction is expected to affect several floors or a large area of the building, consider moving occupants from that area until construction is completed.

The level of containment can be minimized if occupants are not present. Complaints from University employees and exposures to construction dust and odors in adjacent occupied areas will be eliminated. Demolition and construction work can be completed without disruption due to repair of dust barriers and occupant complaints.

Level 1 - Initial control options, which should be considered for all projects:

- Send a written notice to building occupants or other potentially affected individuals informing them about the start of construction, expected noise, dust and/or odor issues, measures to be taken to control these issues, and expected ending date.
- Close doors surrounding the construction. Install gaskets and door sweeps on doors.
- Evaluate supply/return duct system. Seal and/or filter return or exhaust ductwork as necessary to isolate construction area.
- Wet materials during demolition so that visible emissions do not occur.
- Cover or wet materials being removed from job site.
- Use cutting tools to remove materials in large pieces. Do not use impact tools to demolish materials.
- Sweep streets near job site frequently enough to prevent visible airborne emissions from impacting normal University operations.
- Wet gravel and/or dirt driveways in construction area especially during dry periods that have heavy traffic flow.

Level 2 - More extensive control options if Level 1 does not work or if project has special considerations:

- Seal around ductwork and pipes with plastic, tape, or caulk.
- Enclose work area with plastic sheets or sheet rock on the construction side of framing. Enclosures must be continuous from the floor to the deck above. Seal joint perimeters with caulk or tape.
- Protect doors and windows on adjacent buildings.
- Protect air intakes on adjacent buildings.
- Maintain airflow from clean areas to dirty areas on the job site. Provide fans or other ventilation equipment to exhaust air from construction areas to the outside. Direct exhaust away from building openings or air intakes.
- Use exhaust devices on tools to capture dust at source.
- Remove construction debris in covered containers and in wet condition.

Level 3 - Additional measures for special projects involving sensitive patient and/or research areas:

- Fully enclose all work areas with sheet rock or plastic sheeting and seal joints or other openings with caulk or tape. Create negative pressure for this enclosed work area by exhausting temporary

ventilation from the work to the exterior.

- Periodically perform particle counts in clean areas and check airflow in adjacent areas to assure that airflow direction is away from clean areas.
- Install air filtration equipment in occupied spaces adjacent to construction area.
- Have construction workers change into clean clothing and/or remove work shoes before entering clean areas.
- Provide an area for workers to cleanup and change into clean clothing.
- Do not transport construction debris through clean areas.
- Schedule all work with the Owner's Representative to ensure that it has a minimal impact on normal University operations.
- Work inside a glove bag. (Glove bags are typically used for asbestos abatement to control dust. They could also be used for other small-scale activities in sensitive areas to control dust migration).

End of Appendix A – Dust, Contaminant and Odor Control Options
University of Minnesota Facilities Management
August 2000

APPENDIX K: SECTION 13280 – HAZARDOUS MATERIALS PROCEDURES

**Please refer to the University of Minnesota Construction Standards,
APPENDIX K, Section 13280 – August 2000**

(<http://www.facm.umn.edu/cons/>)

SECTION 23 2113

HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes piping, special-duty valves, and hydronic specialties for chilled-water and hot-water systems.

1.2 SUBMITTALS

- A. Product Data: For each type of special-duty valve indicated. Include flow and pressure drop curves based on manufacturer's testing for diverting fittings, calibrated balancing valves, and automatic flow-control valves.
- B. Shop Drawings: Detail fabrication of pipe anchors, hangers, special pipe support assemblies, alignment guides, expansion joints and loops, and their attachment to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
- C. Welding Certificates: Copies of certificates for welding procedures and personnel.
- D. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Failed test results and corrective action taken to achieve requirements.
- E. Maintenance Data: For hydronic specialties and special-duty valves to include in maintenance manuals specified in Division 1.

1.3 QUALITY ASSURANCE

- A. Welding: Qualify processes and operators according to the ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
- B. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1.4 COORDINATION

- A. Coordinate layout and installation of hydronic piping and suspension system components with other construction.
- B. Coordinate pipe sleeve installations for foundation wall penetrations.

- C. Coordinate piping installation with roof curbs, equipment supports, and roof penetrations.
- D. Coordinate pipe fitting pressure classes with products specified in related Sections.
- E. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base.
- F. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Coordinate with requirements for firestopping specified in Division 7 Section "Penetration Firestopping" for fire and smoke wall and floor assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Calibrated Balancing Valves:
 - a. Armstrong Pumps, Inc.
 - b. Flow Design, Inc.
 - c. Gerand Engineering Company.
 - d. Griswold Controls.
 - e. ITT Bell & Gossett; ITT Fluid Technology Corp.
 - f. Taco, Inc.
 - 2. Pressure-Reducing Valves:
 - a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. ITT Bell & Gossett; ITT Fluid Technology Corp.
 - d. Watts Industries, Inc.; Watts Regulators.
 - 3. Safety Valves:
 - a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Conbraco Industries, Inc.
 - d. ITT McDonnell & Miller Div.; ITT Fluid Technology Corp.
 - 4. Expansion Tanks:
 - a. Armstrong Pumps, Inc.
 - b. ITT Bell & Gossett; ITT Fluid Technology Corp.
 - c. Taco, Inc.
 - 5. Air Separators and Air Purgers:
 - a. Armstrong Pumps, Inc.

- b. ITT Bell & Gossett; ITT Fluid Technology Corp.
- c. Taco, Inc.

2.2 PIPING MATERIALS

- A. General: Refer to Part 3 "Piping Applications" Article for applications of pipe and fitting materials.

2.3 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type K or L.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.
- E. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (silver).

2.4 STEEL PIPE AND FITTINGS

- A. Steel Pipe, NPS 2 and Smaller: ASTM A 53, Type S (seamless), Grade A, Schedule 40, black steel, plain ends.
- B. Steel Pipe, NPS 2-1/2 through NPS 12: ASTM A 53, Type E or Type S Grade A.
- C. Steel Pipe, NPS 14 through NPS 18: ASTM A 53, Type E or Type S Grade B.
- D. Steel Pipe, NPS 20 and up: ASTM A 53, Type E or Type S Grade B .
 - 1. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53, Schedule 40, black steel; seamless for NPS 2 and smaller and electric-resistance welded for NPS 2-1/2 and larger.
- E. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300.
- F. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300.
- G. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250: raised ground face, and bolt holes spot faced.
- H. Wrought-Steel Fittings: ASTM A 234, wall thickness to match adjoining pipe.
- I. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - 1. Material Group: 1.1.
 - 2. End Connections: Butt welding.
 - 3. Facings: Raised face.
 - 4. Provide Isolation flanges at building entrances where shown on the drawings.
- J. Flexible Connectors: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket; 150-psig minimum working pressure and 250 deg F

maximum operating temperature. Connectors shall have flanged or threaded-end connections to match equipment connected and shall be capable of 3/4-inch misalignment.

- K. Welding Materials: Comply with Section II, Part C, of the ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.
- L. Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures.

2.5 VALVES

- A. Gate, globe, check, ball, and butterfly valves are specified in Division 23 Section "HVAC General Duty Valves."
- B. Refer to Part 3 "Valve Applications" Article for applications of each valve.
- C. Calibrated Balancing Valves, NPS 2 and Smaller: Bronze body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature, and having threaded ends. Valves shall have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.
- D. Calibrated Balancing Valves, NPS 2-1/2 and Larger: Cast-iron or steel body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature, and having flanged or grooved connections. Valves shall have calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, and be equipped with a memory stop to retain set position.
- E. Pressure-Reducing Valves: Diaphragm-operated, bronze or brass body with low inlet pressure check valve, inlet strainer removable without system shutdown, and noncorrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory set at operating pressure and have capability for field adjustment.
- F. Safety Valves: Diaphragm-operated, bronze or brass body with brass and rubber, wetted, internal working parts; shall suit system pressure and heat capacity and shall comply with the ASME Boiler and Pressure Vessel Code, Section IV.

2.6 SPECIALTIES

- A. Manual Air Vent: Bronze body and nonferrous internal parts; 150-psig working pressure; 225 deg F operating temperature; manually operated with screwdriver or thumbscrew; with NPS 1/8 discharge connection and NPS 1/2 inlet connection.
- B. Automatic Air Vent: Designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150-psig working pressure; 240 deg F operating temperature; with NPS 1/4 discharge connection and NPS 1/2 inlet connection.
- C. Expansion Tanks: Welded carbon steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Separate air charge from system water to maintain design expansion capacity by a flexible Butyl rubber bladder securely sealed

into tank. Include drain fitting and taps for pressure gage and air-charging fitting. Support vertical tanks with steel legs or base; support horizontal tanks with steel saddles. Factory fabricate and test tank with taps and supports installed and labeled according to the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

- D. Tangential-Type Air Separators: Welded black steel; ASME constructed and labeled for 125-psig minimum working pressure and 350 deg F maximum operating temperature; perforated stainless-steel air collector tube designed to direct released air into expansion tank; tangential inlet and outlet connections; threaded connections for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger; threaded blowdown connection. Provide units in sizes for full-system flow capacity.
- E. Y-Pattern Strainers: 125-psig working pressure; cast-iron body (ASTM A 126, Class B), flanged ends for NPS 2-1/2 and larger, threaded connections for NPS 2 and smaller, bolted cover, perforated stainless-steel basket, and bottom drain connection.
- F. Stainless-steel bellow, flexible connectors: Stainless steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket, 150 psig working pressure with threaded or flanged ends to match connected equipment. Connector shall be capable of 3/4-inch misalignment.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Hot Water Heating, NPS 2 and Smaller: Standard weight ASTM A53 or A120 continuous weld black steel pipe with standard weight cast iron threaded fittings or Type L copper with lead-free soldered joints.
- B. Hot Water Heating, NPS 2-1/2 thru NPS 12: Standard weight ASTM A53 or A120 continuous weld black steel pipe with welded fittings and 150 class weld NECX or slip-on flanges.
- C. Chilled Water, Glycol and Heat Recovery, NPS 2 and smaller: Standard weight ASTM A53 or A120 continuous weld black steel pipe with standard weight cast iron threaded fittings.
- D. Chilled water, Glycol and Heat Recovery, NPS 2-1/2 and larger: Standard weight ASTM A53 or A120 continuous weld black steel pipe with welded fittings and 150 class weld neck or slip-on flanges.
- E. Chilled water, Glycol and Heat Recovery, NPS 2-1/2 and smaller: May be type K copper with lead-free solder points.

3.2 VALVE APPLICATIONS

- A. General-Duty Valve Applications: Unless otherwise indicated, use the following valve types:
 - 1. Shutoff Duty: Gate, ball, and butterfly valves.
 - 2. Throttling Duty: Butterfly valves.

- B. Install shutoff duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, unless only one piece of equipment is connected in the branch line. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.
- C. Install check valves at each pump discharge and elsewhere as required to control flow direction.

3.3 PIPING INSTALLATIONS.

- A. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- B. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- C. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- D. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- E. Unless otherwise indicated, install branch connections to mains using tee fittings in main pipe, with the takeoff coming out the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.
- F. Install strainers on supply side of each pump and heat exchanger supply connections. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger.
- G. Anchor piping for proper direction of expansion and contraction.

3.4 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor devices are specified in Division 23 Section "HVAC Hangers and Supports."

3.5 PIPE JOINT CONSTRUCTION

- A. Refer to Division 23 Section "HVAC Materials and Methods" for joint construction requirements for soldered and brazed joints in copper tubing; threaded, welded, and flanged joints in steel piping.

3.6 CORROSION PROTECTION

- A. General
 - 1. Install chilled water piping in accordance with the Drawings, this Specification and approved submittals.
 - 2. Provide electrical isolation for buried piping.
- B. Field Wrapping and Coating of buried piping.
 - 1. Field wrap and coat valves, fittings, bare pipe at welds, flanges, bolts, and other bare metal after successful hydrostatic testing.

2. Tape coat pipe line tape or equal may be used for this purpose when selected and applied in accordance with recommendations of manufacturer for the intended service.
 3. Exercise proper caution to avoid damaging protective coatings/wraps. Repair any damaged coatings.
- C. Electrical Inspection of Coatings
1. Contractor shall field inspect the entire cathodic protection system in the presence of the Engineer and the Owner.
 - a. Establish and document that voltage between testing electrode and coated metal structure is adequate for coating thickness and type of coating. Provide and demonstrate to the Engineer a sample of coated pipe with a holiday of 1/8" diameter and show that the holiday detector functions properly.
 - b. Establish and document that the ground system and coated metal structure have minimum of electrical resistance between them.
 - c. Use holiday detector with audible alarm to signal spark jumping between electrode and metal structure. Test in the presence of the cathodic system designer.
 - d. Provide complete checkout of coating system. Checkout shall be certified by contractor and system designer. Provide written report of test results and certification of adequacy of system.
- D. Installation of Cathodic Protection
1. Cathodic protection system installation includes installation of electrical work, wiring, fittings, anodes, bonding, thermite brazing and other work required for a complete and functioning cathodic protection system.
 2. Comply with anode location and spacing, pipe attachment method distance from pipe to anode, burial depth of anode and other applicable details of anode installation as recommended by the cathodic protection system designer and supplier.
 3. Provide complete checkout of system. Checkout shall be certified by contractor and system designer. Provide written report of test results and certification of adequacy of system.

3.7 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping and elsewhere as required for system air venting and 3/4 NTP drains with hose bibs at all low points.
- B. Install automatic air vents in mechanical equipment rooms only at high points of system piping.
- C. Install flexible connectors on suction and discharge of all pumps and equipment where indicated on plans.

3.8 FIELD QUALITY CONTROL

- A. Prepare piping according to 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 system with clean water. Clean strainers.
 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 5. Install safety 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 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 trapped air. Use drains installed at low points for complete draining of liquid.
 3. Check expansion tanks to determine that they are not air bound and that system is full of water.
 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure. Test pressure shall not 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 either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A of ASME B31.9, "Building Services Piping."
 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.

3.9 CLEANING AND CHEMICAL PRETREATING

- A. Cleaning and disinfecting shall be done by the university water treatment supplier, and included in the contractor's bid. Coordinate cleaning and disinfecting operation with the university zone personal. Disinfecting shall be done to meet the minimum requirements that DEHS defines.
- B. Provide Minimum 2" temporary bypass piping at each building connection so that the new piping can be cleaned, flushed and pre-treated with corrosion inhibitor. Corrosion inhibiting pre-treatment chemical shall not contact existing piping.

- C. After hydrostatic testing, and prior to operational testing, thoroughly clean piping with a caustic soda, trisodium phosphate or equal chemical cleaner. Thoroughly flush piping systems with clean water. Remove and clean or replace strainer screens. After cleaning and flushing piping systems remove disposable fine-mesh strainers in pump suction diffusers. Provide documentation to the Owner that the new piping is cleaned and pre-treated and ready for use. After initial cleaning, the owner's representative or designee shall sign and certify that the system has been thoroughly cleaned.
- D. Provide a temporary pot feeder connected to the new piping (if new piping is steel) for use in chemical pre-treatment of the piping. Owner will furnish chemical (Nalco 2578) for pre-treatment. Coordinate with Owner's chemical supplier and operators and provide chemical pre-treatment in accordance with chemical supplier's requirements.
- E. Contractor may present to the Owner a plan to clean piping in the field prior to assembly and to maintain Owner approved cleanliness of the piping throughout the construction process. If the Owner approves such a plan the contractor may proceed. If it is determined that the interior of the chilled water piping is not properly clean, then the Owner may, at its discretion decide to require the contractor to perform the chemical cleaning process in steps B and C above. Step D shall be performed regardless of cleaning method.

END OF SECTION 23 2110

SECTION 23 2123

HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following categories of hydronic pumps for hydronic systems:
 - 1. In-line circulators.
 - 2. Vertical in-line pumps.
 - 3. End-suction pumps.
- B. Related Sections include the following:
 - 1. Division 23 Section "HVAC Motors" for general motor requirements.
 - 2. Division 23 Section "HVAC Vibration Controls and Seismic Restraints" for inertia pads, isolation pads, spring supports, and spring hangers.
 - 3. Division 26 Section "Variable-Frequency-Frequency Motor Controllers."

1.3 SUBMITTALS

- A. Product Data: Include certified performance curves and rated capacities; shipping, installed, and operating weights; furnished specialties; final impeller dimensions; and accessories for each type of product indicated. Indicate pump's operating point on curves.
- B. Shop Drawings: Show pump layout and connections. Include Setting Drawings with templates for installing foundation and anchor bolts and other anchorages.
 - 1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.
- C. Maintenance Data: For pumps to include in operation maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

- A. UL Compliance: Fabricate and label pumps to comply with UL 778, "Motor-Operated Water Pumps," for construction requirements.
- B. Product Options: Drawings indicate size, profiles, connections, and dimensional requirements of pumps and are based on the specific types and models indicated. Other

manufacturers' pumps with equal performance characteristics may be considered. Refer to Division 1 Section "Substitution Procedures."

- 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.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.
- B. Store pumps in dry location.
- C. Retain protective covers for flanges and protective coatings during storage.
- D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.
- E. Comply with pump manufacturer's written rigging instructions.

1.6 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

1.7 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. Mechanical Seals: One mechanical seal for each pump.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. In-Line Circulators:
 - a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Bell & Gossett ITT; Div. of ITT Fluid Technology Corp.
 - d. Taco; Fabricated Products Div.
 - 2. Compact In-Line Circulators:
 - a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Bell & Gossett ITT; Div. of ITT Fluid Technology Corp.

- d. Grundfos Pumps Corp.
- e. PACO Pumps.
- f. Taco; Fabricated Products Div.
- 3. Vertical In-Line Pumps:
 - a. Armstrong Pumps, Inc.
 - b. Bell & Gossett ITT; Div. of ITT Fluid Technology Corp.
 - c. Goulds Pumps, Inc.
 - d. Patterson Pump Co.
 - e. Peerless Pump Co.
 - f. Taco; Fabricated Products Div.
- 4. Flexible -Coupled, End-Suction Pumps:
 - a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Bell & Gossett ITT; Div. of ITT Fluid Technology Corp.
 - d. PACO Pumps.
 - e. Taco; Fabricated Products Div.

2.2 GENERAL PUMP REQUIREMENTS

- A. Pump Units: Factory assembled and tested.
- B. Motors: Include built-in, thermal-overload protection and grease-lubricated ball bearings. Select each motor to be nonoverloading over full range of pump performance curve.
- C. Motors Indicated to Be Energy Efficient: Minimum efficiency as indicated according to IEEE 112, Test Method B. Include motors with higher efficiency than "average standard industry motors" according to IEEE 112, Test Method B, if efficiency is not indicated.

2.3 IN-LINE CIRCULATORS

- A. Description: Horizontal, in-line, centrifugal, single-stage, bronze-fitted, radially split case design; rated for 125-psig minimum working pressure and a continuous water temperature of 225 deg F.
 - 1. Casing: Cast iron, with threaded companion flanges for piping connections, and threaded gage tappings at inlet and outlet connections.
 - a. Connection Option: Unions at connections for casings that are not available with threaded companion flanges. Impeller: ASTM B 36, rolled-temper-brass fabrication, statically and dynamically balanced, closed, overhung, single suction, and keyed to shaft.
 - 2. Shaft and Sleeve: Steel shaft with oil-lubricated copper sleeve.

3. Seals: Mechanical type. Include carbon-steel rotating ring, stainless-steel spring, ceramic seat, and flexible bellows and gasket.
4. Pump Bearings: Oil-lubricated, bronze journal and thrust type.
5. Motor Bearings: Oil-lubricated, sleeve type.
6. Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.
7. Motor: Resiliently mounted to pump casing.

2.4 COMPACT IN-LINE CIRCULATORS

- A. Description: Cartridge type, horizontal, in-line, compact, seal-less, centrifugal, and single stage. Include pump and motor assembled on a common shaft in cartridge-type, hermetically sealed unit, without stuffing boxes or mechanical seals. Include isolation of motor section from motor-stator windings by corrosion-resistant, nonmagnetic, alloy liner. Include design rated for 125-psig minimum working pressure and a continuous water temperature of 225 deg F.
1. Casing: Cast bronze or cast iron, with stainless-steel liner, static O-ring seal to separate motor section from motor stator, and flanged piping connections.
 2. Impeller: Overhung, single suction, closed or open, nonmetallic.
 3. Shaft and Sleeve: Stainless-steel shaft with carbon-steel sleeve.
 4. Motor: Single speed.

2.5 VERTICAL IN-LINE PUMPS

- A. Description: Vertical, in-line, centrifugal, flexible-coupled, single-stage, radially split case design. Include vertical-mounting, bronze-fitted design and mechanical seals rated for 125-psig minimum working pressure and a continuous water temperature of 225 deg F.
1. Casing: Cast iron, with threaded companion flanges for piping connections smaller than NPS 3, drain plug at low point of volute, and threaded gage tappings at inlet and outlet connections.
 2. Impeller: ASTM B 584, cast bronze, statically and dynamically balanced, closed, overhung, single suction, and keyed to shaft.
 3. Wear Rings: Replaceable, bronze casing ring.
 4. Shaft and Sleeve: Ground and polished stainless-steel shaft with bronze sleeve.
 5. Shaft: Ground and polished stainless-steel shaft with axially split spacer coupling.
 6. Seals: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and flexible bellows and gasket.
 7. Motor: Directly mounted to pump casing and with lifting and supporting lugs in top of motor enclosure.

2.6 FLEXIBLE-COUPLED, END-SUCTION PUMPS

- A. Description: Base-mounted, centrifugal, flexible-coupled, end-suction, single-stage, bronze-fitted, back-pull-out, radially split case design; rated for 175-psig minimum working pressure and a continuous water temperature of 225 deg F.
1. Casing: Cast iron, with flanged piping connections, drain plug at low point of volute, threaded gage tappings at inlet and outlet connections, and integral feet or other means on volute to support weight of casing and attached piping. Casing shall allow removal and replacement of impeller without disconnecting piping.
 2. Impeller: ASTM B 584, cast bronze, statically and dynamically balanced, closed, overhung, single suction, keyed to shaft, and secured by locking cap screw.
 3. Wear Rings: Replaceable, bronze casing ring.
 4. Shaft and Sleeve: Steel shaft with bronze sleeve.
 5. Seals: Mechanical, with carbon-steel rotating ring, stainless-steel spring, ceramic seat, and flexible bellows and gasket.
 6. Seals: Stuffing box, with at least four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
 7. Coupling: Flexible-spacer type, capable of absorbing torsional vibration and shaft misalignment; with flange and sleeve section that can be disassembled and removed without removing pump or motor.
 8. Coupling Guard: Steel, removable, and attached to mounting frame.
 9. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36 channels and angles. Fabricate for mounting pump casing, coupling guard, and motor. Field-drill motor-mounting holes for field-installed motors.
 - a. Option: Cast-iron frames are acceptable.
 10. Motor: Secured to mounting frame, with adjustable alignment.

2.7 PUMP SPECIALTY FITTINGS

- A. Suction Diffuser: Angle or straight pattern, 175-psig pressure rating, cast-iron body and end cap, pump-inlet fitting; with bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory- or field-fabricated support.
- B. Triple-Duty Valve: Angle or straight pattern, 175-psig pressure rating, cast-iron body, pump-discharge fitting; with drain plug and bronze-fitted shutoff, balancing, and check valve features.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation.
 - 1. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
 - 2. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION

- A. Install pumps according to manufacturer's written instructions.
 - 1. Install pumps according to HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation."
- B. Install pumps to provide access for periodic maintenance, including removing motors, impellers, couplings, and accessories.
- C. Support pumps and piping separately so piping is not supported by pumps.
- D. Suspend in-line pumps using continuous-thread hanger rod and vibration-isolation hangers.
- E. Set base-mounted pumps on concrete foundation. Disconnect coupling halves before setting. Do not reconnect couplings until alignment operations have been completed.
 - 1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches between pump base and foundation for grouting.
 - 2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

3.3 ALIGNMENT

- A. Align pump and motor shafts and piping connections after setting them on foundations, after grout has been set and foundation bolts have been tightened, and after piping connections have been made.
- B. Comply with pump and coupling manufacturers' written instructions.
- C. Adjust pump and motor shafts for angular and offset alignment by methods specified in HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation."
- D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.4 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to pumps. Install valves that are the same size as piping connected to pumps.
- D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- E. Install check valve and throttling valve on discharge side of in-line circulators.
- F. Install nonslam check valve and globe valve on discharge side of vertical in-line pumps.
- G. Install suction diffuser and shutoff valve on suction side of vertical in-line pumps.
- H. Install triple-duty valve on discharge side of vertical in-line pumps.
- I. Install suction diffuser and shutoff valve on suction side of base-mounted pumps.
- J. Install triple-duty valve on discharge side of base-mounted pumps.
- K. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- L. Install pressure gages on pump suction and discharge. Install at integral pressure-gage tappings where provided.
- M. Install temperature and pressure-gage connector plugs in suction and discharge piping around each pump.
- N. Install electrical connections for power, controls, and devices.
- O. Electrical power and control wiring and connections are specified in Division 26 Sections.
- P. Ground equipment.
 - 1. 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 and UL 486B.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps as specified below:
 - 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining pumps.
 - 2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."
 - 3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."

4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 23 2123

SECTION 23 22 13

STEAM AND CONDENSATE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following for LP and HP steam and condensate piping:
 - 1. Pipe and fittings.
 - 2. Strainers.
 - 3. Flash tanks.
 - 4. Safety valves.
 - 5. Steam traps.
 - 6. Thermostatic air vents and vacuum breakers.
 - 7. Steam and condensate meters.

1.3 DEFINITIONS

- A. HP Systems: High-pressure piping operating at more than 15 psig as required by ASME B31.1.
- B. LP Systems: Low-pressure piping operating at 15 psig or less as required by ASME B31.9.

1.4 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures:
 - 1. LP Steam Piping: 75 psig and 350°F.
 - 2. Condensate Piping: Equal to pressure and temperature of the piping system to which it is attached.
 - 3. Pumped Condensate Piping: 125 psig at 350°F.
 - 4. Blowdown-Drain Piping: Equal to pressure and temperature of the piping system to which it is attached.
 - 5. Air-Vent and Vacuum-Breaker Piping: Equal to pressure and temperature of the piping system to which it is attached.
 - 6. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure and temperature of the piping system to which it is attached.

1.5 SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Strainer.

2. Pressure-reducing and safety valve.
 3. Steam trap.
 4. Air vent and vacuum breaker.
 5. Flash tank.
 6. Meter.
- B. Shop Drawings: Detail, flash tank assemblies and fabrication of pipe anchors, hangers, pipe, multiple pipes, alignment guides, and expansion joints and loops and their attachment to the building structure. Detail locations of anchors, alignment guides, and expansion joints and loops.
- C. Qualification Data: For Installer.
- D. Welding certificates.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, strainers and meters to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code - Steel."
- B. Pipe Welding: Qualify processes and operators according to the following:
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.
- C. Code Compliance: Comply with Minnesota Code for High Pressure Piping, Chapter 5230, Minnesota Building Code Mechanical Systems Chapter 1345 ASME B31.1, "Power Piping" and ASME B31.9, "Building Services Piping" for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53 or ASTM 106, black steel, plain ends, Type, Grade, and Schedule as indicated in Part 3 piping applications articles. Dimensions conforming to ASME B36.10.
- B. Malleable-Iron Threaded Fittings: ASME B16.3; Classes 150 and 300 as indicated in Part 3 piping application articles.
- C. Forged Steel Threaded and Socket-Welding Fitting: ASME B16.11, MSS-SP-83, Classes 2000, 3000 as indicated in Part 3 piping applications articles.
- D. Wrought-Steel Welding Fittings: ASTM A 234 WPB Seamless, ASME B16.9, wall thickness to match adjoining pipe.

- E. Forged-Steel Flanges: ASME B16.5, of the following material end connections, and facings:
 - 1. Material: ASTM A105.
 - 2. End Connections: Butt welding neck.
 - 3. Facings: Raised face.
- F. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53 or ASTM A106, black steel of same Type, Grade, and Schedule as pipe in which installed.
- G. Stainless-Steel Bellows, Flexible Connectors:
 - 1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforced, protective jacket.
 - 2. End Connections: Threaded or flanged to match equipment connected.
 - 3. Performance: Capable of 3/4-inch misalignment.
 - 4. CWP Rating: 250-psig.
 - 5. Maximum Operating Temperature: 500 deg F.

2.2 JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical pressure and thermal conditions of piping system contents.
 - 1. ASME B16.20 metallic, spiral-wound stainless steel and graphite, 1/8" thick.
- B. ASTM A193 Gr. B7 Studs, ASTM A-194, Grade 2H heavy hex nuts; ASME B18.2.1 and ASME B18.2.2.
- C. Welding Materials: Comply with Section II, Part C, of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

2.3 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:
 - 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. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Hart Industries, International Inc.
 - d. Watts Water Technologies, Inc.
 - e. Zurn Plumbing Products Group.
 - 2. Factory-fabricated union assembly, suitable for pressure and temperature rating of joined system.
- D. Dielectric Flanges:

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. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Watts Water Technologies, Inc..
 2. Factory-fabricated companion-flange assembly, for minimum working pressure and temperature as required to suit system requirements.
- E. Dielectric-Flange Kits:
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. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Central Plastics Company.
 - d. Pipeline Seal and Insulator, Inc.
 2. 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.
 3. Separate companion flanges and steel bolts and nuts shall have minimum working pressure and temperature as required to suit system requirements.

2.4 VALVES

- A. Quarter-Turn Rotary Process Valves
1. Quarter-Turn Rotary Process Valves, HP Systems:
 - a. Manufacturers:
 - (1) Tyco Valves & Controls, Vanessa Series 30,000 QTF
 - b. Body: Cast Steel ASTM A216 WCB
 - c. Body Style: double-flanged (ISO 5752 Table 1 Col. 13)
 - d. End Connections: ASME B16.5 Class 300
 - e. Seat: Stellite Gr. 21 weld overlay
 - f. Disc: ASTM A216 WCB nickel-plated
- B. Gate Valves
1. Gate Valves, LP Systems, Up To and Including 2 Inches NPS:
 - a. Manufacturers:
 - (1) Bonney Forge, fig. W-11-T
 - b. Class: 800
 - c. Body: Forged steel
 - d. End Connections: threaded
 - e. Outside steam and yoke
 - f. Rising stem
 - g. Seat Rings: stainless steel

- h. Wedge: solid
- i. Bonnet: threaded and seal welded
- 2. Gate Valves, LP Systems, 2 ½” Inches NPS and larger:
 - a. Manufacturers:
 - (1) Milwaukee Valve Company, model 1550
 - b. Class: 150
 - c. Body: cast steel
 - d. End Connections: butt weld
 - e. Outside steam and yoke
 - f. Rising stem
 - g. Seat Rings: stainless steel
 - h. Wedge: solid
- C. Swing Check Valves
 - 1. Swing Check Valves, LP Systems, up to and including 2 inches NPS:
 - a. Manufacturers:
 - (1) Milwaukee Valve Company, model 510
 - b. Class: 300
 - c. Body: bronze
 - d. End Connections: threaded
 - 2. Swing Check Valves, LP Systems, over 2 inches NPS:
 - a. Manufacturer:
 - (1) Milwaukee Valve Company, model 1570
 - b. Class: 150
 - c. Body: cast steel
 - d. End Connections: flanged
 - e. Style: non-slam, replaceable disc
 - f. Bonnet: bolted
- D. Globe Valves
 - 1. Globe Valves, LP Systems, Up To and Including 2 Inches NPS:
 - a. Manufacturers:
 - (1) Bonney Forge, fig. W-30
 - b. Class: 800
 - c. Body: Forged steel
 - d. End Connections: threaded
 - e. Outside steam and yoke
 - f. Rising stem
 - g. Disc: stainless steel, loose, solid, integral backseat
 - h. Seat: stainless steel
 - i. Packing Gland: two-piece, self-aligning
 - j. Port: full

- k. Bonnet: threaded and seal welded
- 2. Globe Valves, LP Systems, 2 ½” Inches NPS and larger:
 - a. Manufacturers:
 - (1) Milwaukee Valve Company, model 1560
 - b. Class: 150
 - c. Body: cast steel
 - d. End Connections: butt weld
 - e. Outside steam and yoke
 - f. Rising stem
 - g. Seat: stainless steel
 - h. Disc: stainless steel
 - i. Bonnet: bolted
- E. Piston Valves
 - 1. Piston Valves:
 - a. Manufacturers:
 - (1) Klinger, model KVSN
 - b. Class: 300
 - c. Body: A216 WCB cast steel
 - d. End Connections: butt weld

2.5 STRAINERS

- A. Y-Pattern Strainers; LP Systems:
 - 1. Body: ASTM A 216, WCB steel.
 - 2. End Connections: Threaded ends for strainers NPS 2and smaller; flanged ends for strainers NPS 2-1/2and larger.
 - 3. Strainer Screen: Brass, 20 mesh strainer.
 - 4. Tapped blowoff plug.
 - 5. ANSI Class 150.

2.6 FLASH TANKS

- A. Shop or factory fabricated of welded steel according to ASME Boiler and Pressure Vessel Code, for 150-psig rating; and bearing ASME label. Fabricate with tappings for low-pressure steam and condensate outlets, high-pressure condensate inlet, air vent, safety valve, and legs.

2.7 SAFETY VALVES

- A. Cast-Iron Safety Valves (LP Systems):
 - 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. Armstrong International, Inc.
 - b. Kunkle Valve; a Tyco International Ltd. Company.
 - c. Spirax Sarco, Inc.

- d. Consolidated Value.
- e. Watts Water Technologies, Inc.
2. Disc Material: Forged copper alloy with bronze nozzle.
3. End Connections: Raised-face flanged inlet and threaded or flanged outlet connections.
4. Spring: Fully enclosed cadmium-plated steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
5. Pressure Class: 250.
6. Drip-Pan Elbow: Cast iron and having threaded inlet, outlet, and drain, with threads complying with ASME B1.20.1.
7. Exhaust Head: Cast iron and having threaded inlet and drain, with threads complying with ASME B1.20.1.
8. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

2.8 STEAM TRAPS

A. Thermostatic Radiator Traps; LP System:

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. Armstrong International, Inc.
 - b. Barnes & Jones, Inc.
 - c. Hoffman Specialty; Division of ITT Industries.
 - d. Spirax Sarco, Inc.
 - e. Sterling.
2. Body: Bronze angle-pattern body with integral union tailpiece and screw-in cap.
3. Trap Type: Balanced-pressure.
4. Bellows: Stainless steel or monel.
5. Head and Seat: Replaceable, hardened stainless steel.
6. Pressure Class: 125.

B. Thermostatic Traps:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong International, Inc., Model AB-2000
 - b. Velan Inc., Model TS250
2. Body: Forged Steel.
3. End Connections: Threaded.
4. Disc and Seat: Stainless steel.
5. Maximum Operating Pressure: 250 psig @ 500°F.
6. Type: Bi-metallic
7. Oriface: Minimum 3/8 inches.

C. Float and Thermostatic Traps, LP Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong International, Inc.
 2. Body and Bolted Cap: ASTM A 126, cast iron.
 3. End Connections: Threaded.
 4. Float Mechanism: Replaceable, stainless steel.
 5. Head and Seat: Hardened stainless steel.
 6. Trap Type: Balanced pressure.
 7. Thermostatic Bellows: Stainless steel or monel.
 8. Thermostatic air vent capable of withstanding 45 deg F of superheat and resisting water hammer without sustaining damage.
 9. Vacuum Breaker: Thermostatic with phosphor bronze bellows, and stainless steel cage, valve, and seat.
 10. Maximum Operating Pressure: 125 psig.
- D. Inverted Bucket Traps, LP Systems:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong International, Inc., Series 880
 2. Body and Cap: Cast iron.
 3. End Connections: Threaded.
 4. Head and Seat: Stainless steel.
 5. Valve Retainer, Lever, and Guide Pin Assembly: Stainless steel.
 6. Bucket: Brass or stainless steel.
 7. Strainer: Integral stainless-steel inlet strainer within the trap body.
 8. Air Vent: Stainless-steel thermostatic vent.
 9. Pressure Rating: 150 psig.

2.9 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS

- A. Thermostatic Air Vents:
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. Armstrong International, Inc.
 - b. Barnes & Jones, Inc.
 - c. Hoffman Specialty; Division of ITT Industries.
 - d. Spirax Sarco, Inc.
 - e. Sterling.
 2. Body: Cast iron, bronze or stainless steel.
 3. End Connections: Threaded.
 4. Float, Valve, and Seat: Stainless steel.
 5. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
 6. Pressure Rating: 300 psig.

7. Maximum Temperature Rating: 500 deg F.
 8. Pressure and Temperature Rating: Equal to rating of piping system to which it is attached.
- B. Vacuum Breakers:
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. Armstrong International, Inc.
 - b. Hoffman Specialty; Division of ITT Industries.
 - c. Johnson Corporation (The).
 - d. Spirax Sarco, Inc.
 2. Body: Cast iron, bronze, or stainless steel.
 3. End Connections: Threaded.
 4. Sealing Ball, Retainer, Spring, and Screen: Stainless steel.
 5. O-ring Seal: EPR.
 6. Pressure and Temperature Rating: Equal to rating of piping system to which it is attached.

2.10 STEAM METERS

- 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. EMCO Flow Systems; Division of Advanced Energy Company.
 2. ISTECH Corp.
 3. Preso Meters; a division of Racine Federated Inc.
 4. Spirax Sarco, Inc.
- B. Sierra Instruments, Inc. All steam meters shall be provided with remote surface-mount electronic totalizers with two clearly identified terminals that allow for the remote readout of consumption. One terminal shall have local readout and the other shall be capable of interfacing with the Building Automation System and BSAC to enable remote reading and data logging.
- C. One remote readout terminal shall be a dry contact type, normally closed, and shall open to indicate a unit of measure. The contact shall be rated for at least two amps at 120 volts. The contact shall remain open for at least 40 milliseconds. The other remote readout terminal shall be 4 mA to 20 mA that is proportional to the flow rate. The totalizers shall be of a backlit LCD type, indicating steam flow and total, as manufactured by Kessler Ellis.
- D. Steam metering systems shall incorporate electronic “peak pickers” that can be reset and store monthly peak flow.
- E. Sensor: Vortex type with stainless-steel wetted parts and flange connections; and with a piezoelectric sensor removable and serviceable without shutting down the process. At least 40:1 turndown with plus or minus 1 percent accuracy over full-flow range.

2.11 CONDENSATE METERS

- A. Manufacturers: Subject to compliance with requirements, provide the following:
 - 1. Niagara, WPX Series.
- B. Body: Cast iron, bronze, or brass.
- C. Rotor: Polyamid, polyetherether ketone.
- D. Connections: Threaded for NPS 1 1/2 and smaller and flanged for NPS 2 and larger.
- E. Totalizer: Meters shall have a microprocessor to display flow, flow rate, time, and date; alarms for high and low flow rate, pressure, and temperature.
 - 1. Computer shall have 4- to 20-mA or 2- to 10-volt output for temperature, pressure, and contact closure for flow increments.
 - 2. Independent timers to store four peak flow rates and total flow.
 - 3. Interface compatible with central workstation specified in Division 23 Section "Instrumentation and Control for HVAC."
 - 4. Microprocessor Enclosure: NEMA 250, Type 4.
- F. Pressure Rating and Temperature: Equal to rating of piping system to which it is attached.

2.12 PRESSURE REDUCING VALVES

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Spence Engineering Co., Type E.
- B. Size, Capacity, and Pressure Rating: Factory set for inlet and outlet pressures indicated.
- C. Description: Pilot-actuated, diaphragm type, with adjustable pressure range and positive shutoff.
- D. Body: Cast steel, ASTM A216 WCB.
- E. End Connections: Threaded connections for valves NPS 2 and smaller and flanged connections for valves NPS 2-1/2 and larger.
- F. Trim: Hardened stainless steel.
- G. Head and Seat: Replaceable, main head stem guide fitted with flushing and pressure-arresting device cover over pilot diaphragm.
- H. Gaskets: Non-asbestos materials.

PART 3 - EXECUTION

3.1 LP STEAM PIPING APPLICATIONS

- A. LP Steam Piping, NPS 2 and Smaller : Schedule 80, Type S, Grade B, steel pipe; Class 150 malleable-iron fittings; and threaded joints.

- B. LP Steam Piping, NPS 2-1/2 through NPS 12]: Schedule 40, Type S, Grade B, steel pipe; wrought steel fittings, Class 150 flanges, and flange fittings; and welded and flanged joints.
- C. LP Steam Piping, NPS 12 and Larger : Schedule 40 or STD, Type S, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.
- D. Condensate piping, NPS 2 and Smaller: Schedule 80, Type S, Grade B, steel pipe; Class 2000 forged steel fittings; and threaded joints.
- E. Condensate piping, NPS 2-1/2 and larger: Schedule 80, Type S, Grade B, steel pipe; wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

3.2 ANCILLARY PIPING APPLICATIONS

- A. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
- B. Air-Vent Piping:
 - 1. Inlet: Same as service where installed.
 - 2. Outlet: Type Kannealed-temper copper tubing with soldered or flared joints.
- C. Vacuum-Breaker Piping: Outlet, same as service where installed.
- D. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.3 VALVE APPLICATIONS

- A. All shutoff valves 3 inch NPS and larger on HP Steam Systems shall be installed with an external warm-up bypass line, including a globe valve and two pressure gauges.
- B. For HP Steam Systems, unless noted otherwise on the drawings:
 - 1. Use quarter-turn rotary process (Vanessa) valves on 3 inch NPS and larger for shut-off and to isolate equipment, parts of systems, or vertical risers;
 - 2. Use gate valves on 1/2" to 2 1/2 inch NPS for shut-off and to isolate equipment, parts of systems, or vertical risers;
 - 3. Use globe valves for throttling, bypass, and manual flow control services;
 - 4. Use piston valves for bypass of steam pressure control valves in pressure reducing station services.
- C. For systems other than HP Steam, unless noted otherwise on the drawings:
 - 1. use gate valves on for shut-off and to isolate equipment, parts of systems, or vertical risers;
 - 2. use globe valves for throttling, bypass, and manual flow control services.
- D. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.
- E. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.4 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Use indicated piping locations and arrangements if such were 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 free of sags and bends.
- G. Install fittings for changes in direction and branch connections.
- H. Install piping to allow application of insulation.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- K. Install drains, consisting of a tee fitting, NPS 3/4 full port-ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- L. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.
- M. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.
- N. Reduce pipe sizes using eccentric reducer fitting installed with level side down.
- O. Install branch connections to mains using **mechanically formed** tee fittings in main pipe, with the branch connected to top of main pipe. Branches 10 inch NPS and smaller in mains 2 or more nominal sizes larger than the branch and NPS 2 1/2 inch or larger may use welded branch connection fitting complying with MSS-SP-97 (Weld-O-let/Sock-O-let).
- P. Install valves according to Division 23 Section "General-Duty Valves for HVAC Piping."
- Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- S. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and full port ball valve in blowdown connection of strainers NPS 3 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 3.

- T. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Division 23 Section "Expansion Fittings and Loops for HVAC Piping."
- U. Identify piping as specified in Division 23 Section "Identification for HVAC Piping and Equipment."
- V. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.
 - 1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding 200 feet.
 - 2. Size drip legs same size as main. In steam mains NPS and larger, drip leg size can be reduced, but to no less than NPS .
- W. Flash Tank:
 - 1. Pitch condensate piping down toward flash tank.
 - 2. If more than one condensate pipe discharges into flash tank, install a check valve in each line.
 - 3. Install thermostatic air vent at tank top.
 - 4. Install safety valve at tank top.
 - 5. Install gate valve, and swing check valve on condensate outlet.
 - 6. Install inverted bucket or float and thermostatic trap at low-pressure condensate outlet, sized for three times the calculated heat load.
- X. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."
- Y. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."
- Z. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section "Escutcheons for HVAC Piping."

3.5 STEAM-TRAP INSTALLATION

- A. Install steam traps in accessible locations as close as possible to connected equipment.
- B. Install gate valve, strainer, and union upstream from trap; install union, drain, check valve, and gate valve downstream from trap unless otherwise indicated. Drain shall consist of a tee fitting, gate valve, threaded nipple and cap.

3.6 PRESSURE REDUCING VALVE INSTALLATION

- A. Install pressure-reducing valves in accessible location for maintenance and inspection.
- B. Install bypass piping around pressure-reducing valves, with globe valve equal in size to area of pressure-reducing valve seat ring, unless otherwise indicated.
- C. Install gate valves on both sides of pressure-reducing valves.
- D. Install unions or flanges on both sides of pressure-reducing valves having threaded- or flanged-end connections respectively.

- E. Install pressure gages on low-pressure side of pressure-reducing valves after the bypass connection according to Division 23 Section "Meters and Gages for HVAC Piping."
- F. Install strainers upstream for pressure-reducing valve.
- G. Install safety valve downstream from pressure-reducing valve station.

3.7 STEAM OR CONDENSATE METER INSTALLATION

- A. Install meters with lengths of straight pipe upstream and downstream according to steam meter manufacturer's instructions.
- B. Provide data acquisition wiring. Refer to Division 23 Section "Instrumentation and Control for HVAC."

3.8 SAFETY VALVE INSTALLATION

- A. Install safety valves according to ASME B31.1, "Power Piping" and ASME B31.9, "Building Services Piping."
- B. Pipe safety-valve discharge without valves to atmosphere outside the building.
- C. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.
- D. Install exhaust head with drain to waste, on vents equal to or larger than NPS 2-1/2.

3.9 HANGERS AND SUPPORTS

- A. Provide hangers and supports according to ASME B311." Comply with requirements below for maximum spacing.
- B. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
 - 2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.
- C. Install hangers with the following maximum spacing and minimum rod sizes:
 - 1. NPS 3/4: Maximum span, 9 feet; minimum rod size, 1/4 inch.
 - 2. NPS 1: Maximum span, 9 feet; minimum rod size, 1/4 inch.
 - 3. NPS 1-1/2: Maximum span, 12 feet; minimum rod size, 3/8 inch.
 - 4. NPS 2: Maximum span, 13 feet; minimum rod size, 3/8 inch.
 - 5. NPS 2-1/2: Maximum span, 14 feet; minimum rod size, 3/8 inch.
 - 6. NPS 3: Maximum span, 15 feet; minimum rod size, 3/8 inch.
 - 7. NPS 4: Maximum span, 17 feet; minimum rod size, 1/2 inch.
 - 8. NPS 6: Maximum span, 21 feet; minimum rod size, 1/2 inch.
- D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
 - 1. NPS 1/2: Maximum span, 4 feet; minimum rod size, 1/4 inch.
 - 2. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.

3. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
 4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
 7. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.
- E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.10 PIPE JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.
- 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. All welding shall be performed by a SMAW Prouss using approved electrodes. Root pass shall be performed with AWS E6010 electrode without backing. Fill and cover passes shall be performed with AWS E7018 electrode.
- F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.11 TERMINAL EQUIPMENT CONNECTIONS

- A. Size for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install traps and 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 vacuum breakers downstream from control valve, close to coil inlet connection.
- E. Install a drip leg at coil outlet.

3.12 FIELD QUALITY CONTROL

- A. A sample of HP system welds shall be examined by X-ray before hydrostatic testing. Engineer and Owner to determine sample number.
- B. Prepare steam and condensate piping according to ASME B31.1, "Power Piping" and ASME B31.9, "Building Services Piping," 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 system with clean water. Clean strainers.
 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 5. Notify Owner at least 24 hours prior to testing. Proceed with testing only with written permission from owner.
- C. Perform the following tests on steam and condensate 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. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not 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.
 3. 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.
- D. Prepare written report of testing.

END OF SECTION 232213

SECTION 23 2500

HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes water-treatment systems for the following:
 - 1. Heating, hot-water piping (closed-loop system).
 - 2. Chilled-water piping (closed-loop system).

1.3 CHEMICAL FEED SYSTEM DESCRIPTION

- A. Closed-Loop System: One bypass feeder on each system with isolating and drain valves downstream from circulating pumps, unless otherwise indicated.
 - 1. Introduce chemical treatment through bypass feeder when required or indicated by test.

1.4 PERFORMANCE REQUIREMENTS

- A. Maintain water quality for HVAC systems that controls corrosion and build-up of scale and biological growth for maximum efficiency of installed equipment without posing a hazard to operating personnel or the environment.
- B. Base chemical treatment performance requirements 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.

1.5 SUBMITTALS

- A. Product Data: Include rated capacities; water-pressure drops; shipping, installed, and operating weights; and furnished products listed below:
 - 1. Test equipment.
 - 2. Chemicals.
 - 3. Filters.
- B. Shop Drawings: Detail equipment assemblies indicating dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

- C. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.
- D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- E. Maintenance Data: For pumps, agitators, filters, system controls, and accessories to include in maintenance manuals specified in Division 1.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who is an authorized representative of the chemical treatment manufacturer for both installation and maintenance of chemical treatment equipment required for this Project.
- 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.

1.7 MAINTENANCE

- A. Scope of Service: Provide service program for maintaining optimum conditions in the circulating water for inhibiting corrosion, scale, and organic growths in the [**cooling, chilled-water piping**] [**heating, hot-water piping**] and equipment. The University shall purchase all chemicals necessary for chemical treatment of the systems. Services shall be provided for a period of one year from date of Substantial Completion, including the following:
 - 1. Initial water analysis and recommendations.
 - 2. Startup assistance.
 - 3. Periodic field service and consultation.
 - 4. Customer report charts and log sheets.
 - 5. Laboratory technical assistance.
 - 6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. HVAC Water-Treatment Products:
 - a. Anderson Chemical Co., Inc.
 - b. DuBois Chemicals, Inc.; DuBois USA Subsidiary.
 - c. Nalco Chemical Co.

2.2 CHEMICAL FEEDING EQUIPMENT

- A. Bypass Feeders: Cast iron or steel, for introducing chemicals into system; with funnel shutoff valve on top, air-release valve on top, drain valve on bottom, and recirculating shutoff valves on sides.
- B. University of Minnesota Requirement: The minimum size of bypass feeder is 5 gallons and shall be service rated for 300 psig per Division 15 section 15749 paragraph 2.1.2 of the 2002 Standards. Retain this section for University projects.
 - 1. Capacity: 5 gal.
 - 2. Working Pressure: 300 psig.

2.3 CHEMICALS

- A. No chemicals are to be provided by the contractor. The University shall purchase all chemicals necessary for the chemical treatment of the system and turn over to the contractor for introduction into the system.
- B. System Cleaner: Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

- A. Perform an analysis of supply water to determine the type and quantities of chemical treatment needed to maintain the water quality as specified in "Performance Requirements" Article.

3.2 INSTALLATION

- A. Install treatment equipment level and plumb.
- B. Add cleaning chemicals as recommended by manufacturer.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.

3.4 FIELD QUALITY CONTROL

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
 - 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.

END OF SECTION 23 2500

SECTION 23 3113

METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus 2- to plus 10-inch wg. Metal ducts include the following:
 - 1. Single-wall, rectangular ducts and fittings.
 - 2. Double-wall, rectangular ducts and fitting.
 - 3. Single-wall, round, spiral-seam ducts and formed fittings.
 - 4. Double-wall, round, spiral-seam ducts and formed fittings.
 - 5. Duct liner.
- B. Related Sections include the following:
 - 1. Division 23 Section "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
 - 2. Division 23 Section "Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 DEFINITIONS

- A. FRP: Fiberglass-reinforced plastic.

1.4 SYSTEM DESCRIPTION

- A. Duct system design, as indicated, has been used to select size and type of air-moving and -distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by Engineer. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.5 SUBMITTALS

- A. Shop Drawings: Drawn to 1/4 inch equals 1 foot scale. Show fabrication and installation details for metal ducts.
 - 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.

2. Fittings.
 3. Reinforcement and spacing.
 4. Seam and joint construction.
 5. Penetrations through fire-rated and other partitions.
 6. Equipment installation based on equipment being used on Project.
 7. Duct accessories, including access doors and panels.
 8. Hangers and supports, including methods for duct and building attachment, vibration isolation, and seismic restraints.
- B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
1. Ceiling suspension assembly members.
 2. Other systems installed in same space as ducts.
 3. Ceiling- and wall-mounting access doors and panels required to provide access to dampers and other operating devices.
 4. Ceiling-mounting items, including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- C. Welding certificates.
- D. Field quality-control test reports.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- B. NFPA Compliance:
1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
 2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

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. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHEET METAL MATERIALS

- A. 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: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.
- 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.

2.3 DUCT LINER

- A. Fibrous-Glass Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124.
 - 1. Manufacturers:
 - (1) CertainTeed Corp.; Insulation Group.
 - (2) Johns Manville International, Inc.
 - (3) Knauf Fiber Glass GmbH.
 - (4) Owens Corning.
 - 2. Materials: ASTM C 1071; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.
 - (1) Thickness: 1 inch.
 - (2) Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
 - (3) Density: 3.0 lb
 - (4) Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
 - (5) Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
 - (6) Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct.
 - (7) Tensile Strength: Indefinitely sustain a 50-lb tensile, dead-load test perpendicular to duct wall.
 - (8) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
 - (9) Adhesive for Attaching Mechanical Fasteners: Comply with fire-hazard classification of duct liner system.

2.4 SEALANT MATERIALS

- A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes tapes and combinations of open-weave fabric strips and mastics. UL listed, rated up to 10 inch pressure class.

1. Tape Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Joint and Seam Sealant: One-part, nonsag, solvent-release-curing, polymerized butyl sealant formulated with a minimum of 75 percent solids.
3. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

2.5 HANGERS AND SUPPORTS

- A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
- B. Hanger Materials: Galvanized sheet steel or threaded steel rod.
 1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
 2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
- C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36.
 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2.6 RECTANGULAR DUCT FABRICATION

- A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
 1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
 2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.
 1. Manufacturers:

- a. Ductmate Industries, Inc.
 - b. Nexus Inc.
 - c. Ward Industries, Inc.
- C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details.
1. Manufacturers:
 - a. Ductmate Industries, Inc.
 - b. Lockformer.
 - c. Ward Industries, Inc.
 2. Duct Size: Maximum 30 inches wide and up to 2-inch wg pressure class.
 3. Longitudinal Seams: Pittsburgh lock sealed with noncuring polymer sealant.
- D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of nonbraced panel area unless ducts are lined.

2.7 APPLICATION OF LINER IN RECTANGULAR DUCTS

- A. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
- B. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
- C. Butt transverse joints without gaps and coat joint with adhesive.
- D. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
- E. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.
- F. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
- G. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 1. Fan discharges.
 2. Intervals of lined duct preceding unlined duct.
 3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm or where indicated.

- H. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.8 ROUND AND FLAT-OVAL DUCT AND FITTING FABRICATION

- A. Diameter as applied to flat-oval ducts in this Article is the diameter of a round duct with a circumference equal to the perimeter of a given size of flat-oval duct.
- B. Round, Spiral Lock Seam Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- C. Flat-Oval, Spiral Lock Seam Ducts: Fabricate supply ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible." Fabricate ducts larger than 72 inches in diameter with butt-welded longitudinal seams.
1. Manufacturers:
 - a. McGill AirFlow Corporation.
 - b. SEMCO Incorporated.
 - c. Sheet Metal Connectors, Inc.
- D. Duct Joints:
1. Ducts up to 20 Inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
 2. Ducts 21 to 72 Inches in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.
 3. Ducts Larger Than 72 Inches in Diameter: Companion angle flanged joints per SMACNA "HVAC Duct Construction Standards--Metal and Flexible," Figure 3-2.
 4. Round Ducts: Prefabricated connection system consisting of double-lipped, EPDM rubber gasket. Manufacture ducts according to connection system manufacturer's tolerances.
 - a. Manufacturers:
 - (1) Lindab Inc.
 - (2) Engineer approved equal
 5. Flat-Oval Ducts: Prefabricated connection system consisting of two flanges and one synthetic rubber gasket.
 - a. Manufacturers:
 - (1) Ductmate Industries, Inc.
 - (2) McGill AirFlow Corporation.
 - (3) SEMCO Incorporated.
 - (4) Sheet Metal Connectors

- E. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.
- F. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.
- G. Fabricate elbows using die-formed, gored or pleated construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Fabricate elbows as follows:
 - 1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
 - 2. Round Elbows 8 Inches and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
 - 3. Round Elbows 9 through 14 Inches in Diameter: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
 - 4. Round Elbows Larger Than 14 Inches in Diameter and All Flat-Oval Elbows: Fabricate gored elbows.
 - 5. Die-Formed Elbows for Sizes through 8 Inches in Diameter and All Pressures 0.040 inch thick with 2-piece welded construction.
 - 6. Round Gored-Elbow Metal Thickness: Same as non-elbow fittings specified above.
 - 7. Flat-Oval Elbow Metal Thickness: Same as longitudinal-seam flat-oval duct specified above.
 - 8. Pleated Elbows for Sizes through 14 Inches in Diameter and Pressures through 10-Inch wg: 0.022 inch.

2.9 DOUBLE-WALL DUCT AND FITTING FABRICATION

- A. Manufacturers:
 - 1. Lindab Inc.
 - 2. McGill AirFlow Corporation.
 - 3. SEMCO Incorporated.
- B. Ducts: Fabricate double-wall (insulated) ducts with an outer shell and an inner duct. Dimensions indicated are for inner ducts.
 - 1. Outer Shell: Base metal thickness on outer-shell dimensions. Fabricate outer-shell lengths 2 inches longer than inner duct and insulation and in metal thickness specified for single-wall duct.

2. Insulation: 1-inch- thick fibrous glass liner as specified in this section. Terminate insulation where double-wall duct connects to single-wall duct or uninsulated components, and reduce outer shell diameter to inner duct diameter.
 - a. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
 3. Solid Inner Ducts (Round): Use the following sheet metal thicknesses and seam construction for round ducts:
 - a. Ducts 3 to 8 Inches in Diameter: 0.019 inch with standard spiral-seam construction.
 - b. Ducts 9 to 42 Inches in Diameter: 0.019 inch with single-rib spiral-seam construction.
 4. Solid Inner Ducts (Rectangular): Use the following sheet metal thicknesses for rectangular ducts:
 - a. Ducts up to 30 Inches in either dimension: 0.028 inch.
 - b. Ducts 31 to 60 Inches in either dimension: 0.034 inch.
 - c. Ducts 61 to 90 Inches in either dimension: 0.040 inch.
 - d. Ducts 91 Inches and greater in either dimension: 0.052 inch.
 5. Perforated Inner Ducts: Fabricate with 0.028-inch thick sheet metal having 3/32-inch-diameter perforations, with overall open area of 23 percent. Cover the insulation face behind the perforated inner duct with a NFPA 90A approved synthetic liner with a minimum thickness of 2-mil.
 6. Maintain concentricity of inner duct to outer shell by mechanical means. Prevent dislocation of insulation by mechanical means.
- C. Fittings: Fabricate double-wall (insulated) fittings with an outer shell and an inner duct.
1. Solid Inner Ducts (Round): Use the following sheet metal thicknesses for round ducts:
 - a. Ducts 3 to 34 Inches in Diameter: 0.028 inch.
 2. Solid Inner Ducts (Rectangular): Use the following sheet metal thicknesses for rectangular ducts:
 - a. Ducts up to 30 Inches in either dimension: 0.034 inch.
 - b. Ducts 31 to 60 Inches in either dimension: 0.040 inch.
 - c. Ducts 61 to 90 Inches in either dimension: 0.052 inch.
 - d. Ducts 91 Inches and greater in either dimension: 0.064 inch.
 3. Perforated Inner Ducts: Fabricate with 0.028-inch-thick sheet metal having 3/32-inch- diameter perforations, with overall open area of 23 percent. Cover the insulation face behind the perforated inner duct with a NFPA 90A approved synthetic liner with a minimum thickness of 2-mil.

PART 3 - EXECUTION

3.1 DUCT APPLICATIONS

- A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following schedule:

Table 3.1a Duct Construction Schedule:

System	SMACNA Duct Pressure Class (Inches wg)							Notes
	Supply	Return		Exhaust		Outside Air		
	Discharge	Suction	Discharge	Suction	Discharge	Suction	Discharge	
SUP-01	+3	-2	+2	-	-	-2	-	1
Downstream of VAVs	+2	-	-	-	-	-	-	

1. Supply pressure indicated is for ductwork upstream of the system terminal units.

- B. Duct Sealing: Unless otherwise indicated, seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" as listed in table 3.1b below for duct pressure class indicated.
1. If approved by the engineer, construction of joints and seams may deviate from specifications above in order to meet seal class requirements.
 2. Seal ducts before external insulation is applied.
 3. Ducts not requiring seam and joint sealing include:
 - (1) Ducts used to transfer air between ceiling plenums.

Table 3.1b Duct Sealing and Allowable Leakage Schedule:

Duct System	SMACNA Duct Seal and Leakage Class					Notes
	Duty	Rectangular		Round		
	Pos/Neg (in wg)	Seal Class	Leakage Class (C _L) (cfm/100 ft ² @ 1"wg)	Seal Class	Leakage Class (C _L) (cfm/100 ft ² @ 1"wg)	
AHU Supply	Pos.	A	6	A	3	
AHU Return	Neg	C	24	C	12	
Downstream of VAV's	Pos.	C	24	C	12	

- C. All ducts shall be galvanized steel except as follows:
1. Acid-Resistant (Fume-Handling) Ducts: Type 304, stainless-steel sheet with No. 4 finish.
- D. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated with the following exceptions:
1. For pressure classes lower than 2-inch wg, seal transverse joints.
 2. SMACNA Seal Class A is required for ducts concealed within shaft enclosures.
- E. Seal ducts before external insulation is applied.
- F. Ducts not requiring seam and joint sealing include:

1. Ducts used to transfer air between ceiling plenums.

3.2 DUCT INSTALLATION

- A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
- B. Construct return air plenum transfer ducts with 1 inch interior duct liner to increase the insertion loss of the transfer duct.
- C. Lined ductwork is only to be used in fabrication of plenum transfer ducts.
- D. Install round and flat-oval ducts in lengths not less than 12 feet unless interrupted by fittings.
- E. Install ducts with fewest possible joints.
- F. Install fabricated fittings for changes in directions, size, and shape and for connections.
- G. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of 3 screws in each coupling.
- H. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.
- I. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- J. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- K. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.
- L. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.
- M. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.
- N. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.
- O. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 15 Section "Duct Accessories." Firestopping materials and installation methods are specified in Division 7 Section "Through-Penetration Firestop Systems."
- P. Protect duct interiors from the elements and foreign materials until building is enclosed. Follow SMACNA's "Duct Cleanliness for New Construction."

3.3 HANGING AND SUPPORTING

- A. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.
- B. Support vertical ducts at maximum intervals of 16 feet and at each floor.
- C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.
- D. Install concrete inserts before placing concrete.
- E. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 1. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

3.4 CONNECTIONS

- A. Make connections to equipment with flexible connectors according to Division 15 Section "Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.5 AIR DUCT LEAKAGE TESTING

- A. Field tests and inspections shall be performed according to SMACNA's "HVAC Air Duct Leakage Test Manual".
 - 1. Contractor shall, after installation and prior to insulating, leak test a representative sample of the following duct systems.
 - (1) Supply air ductwork upstream of reheat coils.
 - 2. Contractor shall notify the Engineer upon completion of duct installation selection of representative test samples. Each sample specimen shall be selected by the Engineer prior to testing and include at least five transverse joints, typical seams, an access door, an elbow and at least two typical branch connections.
 - 3. Once representative test samples are selected, contractor shall notify parties whose presence is necessary for the test; and in all cases, the Engineer and Owner's project manager at least two days' in advance of testing.
 - 4. The contractor shall disassemble, reassemble, and cap segments of systems to accommodate leakage testing and for compliance with test requirements.
 - (1) With the exception of end cap sealing, field application of joint sealant shall not be applied to the test sample prior to the leak test.
 - 5. Tests shall be conducted at static pressures equal to maximum design pressure of system or section being tested. Do not pressurize systems above maximum design operating pressure.
 - 6. The leakage amount shall not exceed the allowed amount for the pressure class or the allotted amount for that portion of the system, whichever is applicable. The maximum allowable leakage shall be as listed in table 3.1b above.

7. While system is under pressure, survey joints for audible leaks. Mark leakage points, shut down blower and make repairs. Retest after duct sealant has dried or cured.
- B. If any specimen fails to meet allowable leakage level, the following requirements shall apply.
1. The contractor shall modify the representative sample to bring into compliance and shall retest it until leakage is equal to or less than the maximum allowable.
 2. Another representative sample will be selected at random for leak testing and shall be tested as outlined above.
 3. Additional costs due to testing and remediation shall be the responsibility of the contractor.
- C. All tests and necessary repairs shall be completed prior to the insulation and concealment of ducts.
- D. The contractor shall prepare test reports according to SMACNA's "HVAC Air Duct Leakage Test Manual" and submit to the Engineer for the record.

END OF SECTION 23 3113

SECTION 23 3300

DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
1. Backdraft dampers.
 2. Volume dampers.
 3. Fire dampers.
 4. Ceiling fire dampers.
 5. Smoke dampers.
 6. Combination fire and smoke dampers.
 7. Duct silencers.
 8. Turning vanes.
 9. Duct-mounted access doors.
 10. Flexible connectors.
 11. Flexible ducts.
 12. Spin-in fittings with integral balancing dampers.
 13. Duct accessory hardware.
- B. Related Sections include the following:
1. Division 28 Section "Fire Alarm" for duct-mounting fire and smoke detectors.
 2. Division 23 Section "HVAC Instrumentation and Controls" for damper actuators.

1.3 SUBMITTALS

- A. Product Data: For the following:
1. Backdraft dampers.
 2. Volume dampers.
 3. Fire dampers.
 4. Ceiling fire dampers.
 5. Smoke dampers.

6. Combination fire and smoke dampers.
 7. Duct silencers.
 8. Turning vanes.
 9. Duct-mounting access doors.
 10. Flexible connectors.
 11. Flexible ducts.
 12. Spin-in fittings with integral balancing dampers.
- 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. Special fittings.
 2. Manual-volume damper installations.
 3. Motorized-control damper installations.
 4. Fire-damper, smoke-damper, and combination fire- and smoke-damper installations, including sleeves and duct-mounting access doors.
 5. Wiring Diagrams: Power, signal, and control wiring.
- C. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

1.4 QUALITY ASSURANCE

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

1.5 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. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

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. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHEET METAL MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.
- B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653 and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. Stainless Steel: ASTM A 480.
- D. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- 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 minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT DAMPERS

- A. Manufacturers:
 - 1. Air Balance, Inc.
 - 2. American Warming and Ventilating.
 - 3. CESCO Products.
 - 4. Duro Dyne Corp.
 - 5. Greenheck.
 - 6. Penn Ventilation Company, Inc.
 - 7. Prefco Products, Inc.
 - 8. Ruskin Company.
 - 9. Vent Products Company, Inc.
- B. Description: Multiple-blade, parallel action gravity balanced, with blades of maximum 6-inch width, with sealed edges, assembled in rattle-free manner with 90-degree stop, steel ball bearings, and axles; adjustment device to permit setting for varying differential static pressure.
- C. Frame: 0.052-inch-thick, galvanized sheet steel, with welded corners and mounting flange.
- D. Blades: 0.025-inch-thick, roll-formed aluminum.
- E. Blade Seals: Neoprene.
- F. Blade Axles: Galvanized steel.

- G. Tie Bars and Brackets: Galvanized steel.
- H. Return Spring: Adjustable tension.

2.4 VOLUME DAMPERS

- A. Manufacturers:
 - 1. Air Balance, Inc.
 - 2. American Warming and Ventilating.
 - 3. Flexmaster U.S.A., Inc.
 - 4. McGill AirFlow Corporation.
 - 5. METALAIRE, Inc.
 - 6. Nailor Industries Inc.
 - 7. Penn Ventilation Company, Inc.
 - 8. Ruskin Company.
 - 9. Vent Products Company, Inc.
 - 10. Sheet Metal Connectors, Inc.
- B. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.
 - 1. Pressure Classes of 3-Inch wg or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.
- C. Standard Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, standard leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.
 - 1. Steel Frames: Hat-shaped, galvanized sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
 - 2. Roll-Formed Steel Blades: 0.064-inch- thick, galvanized sheet steel.
 - 3. Blade Axles: Galvanized steel.
 - 4. Bearings: Molded synthetic.
 - 5. Tie Bars and Brackets: Galvanized steel.
- D. Low-Leakage Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, low-leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.

1. Steel Frames: U-shaped, galvanized sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
 2. Roll-Formed Steel Blades: 0.064-inch- thick, galvanized sheet steel.
 3. Blade Axles: Galvanized steel.
 4. Bearings: Molded synthetic thrust or ball.
 5. Blade Seals: Neoprene.
 6. Jamb Seals: Cambered aluminum.
 7. Tie Bars and Brackets: Galvanized steel.
- E. Jackshaft: 1-inch- diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
1. Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.
- F. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

2.5 FIRE DAMPERS

- A. Manufacturers:
1. Air Balance, Inc.
 2. CESCO Products.
 3. Greenheck.
 4. McGill AirFlow Corporation.
 5. METALAIRE, Inc.
 6. Nailor Industries Inc.
 7. Penn Ventilation Company, Inc.
 8. Prefco Products, Inc.
 9. Ruskin Company.
 10. Vent Products Company, Inc.
 11. Ward Industries, Inc.
- B. Fire dampers shall be labeled according to UL 555.
- C. Fire Rating: 1-1/2 hours unless otherwise noted.
- D. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.
- E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
1. Minimum Thickness: 0.052 inch thick and of length to suit application.

2. Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.
- F. Mounting Orientation: Vertical or horizontal as indicated.
- G. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.
- H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- I. Fusible Links: Replaceable, 165 deg F rated.

2.6 CEILING FIRE DAMPERS

- A. Manufacturers:
 1. Air Balance, Inc.
 2. CESCO Products.
 3. Greenheck.
 4. McGill AirFlow Corporation.
 5. METALAIRE, Inc.
 6. Nailor Industries Inc.
 7. Penn Ventilation Company, Inc.
 8. Prefco Products, Inc.
 9. Ruskin Company.
 10. Vent Products Company, Inc.
 11. Ward Industries, Inc.
- B. General Description: Labeled according to UL 555C; comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."
- C. Frame: Galvanized sheet steel, round or rectangular, style to suit ceiling construction.
- D. Blades: Galvanized sheet steel with refractory insulation.
- E. Fusible Links: Replaceable, 165 deg F rated.

2.7 SMOKE DAMPERS

- A. Manufacturers:
 1. Air Balance, Inc.
 2. CESCO Products.
 3. Greenheck.
 4. Nailor Industries Inc.

5. Penn Ventilation Company, Inc.
 6. Ruskin Company.
- B. General Description: Labeled according to UL 555S. Combination fire and smoke dampers shall be labeled according to UL 555 for 1-1/2-hour rating.
- C. Frame and Blades: 0.064-inch- thick, galvanized sheet steel.
- D. Mounting Sleeve: Factory-installed, 0.052-inch-thick, galvanized sheet steel; length to suit wall or floor application.
- E. Damper Motors: Provide for two-position action.
1. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 2. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
 3. Outdoor Motors and Motors in Outside-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
 4. Electrical Connection: 115 V, single phase, 60 Hz.

2.8 COMBINATION FIRE AND SMOKE DAMPERS

- A. Manufacturers:
1. Air Balance, Inc.
 2. CESCO Products.
 3. Greenheck.
 4. Nailor Industries Inc.
 5. Penn Ventilation Company, Inc.
 6. Ruskin Company.
- B. General Description: Labeled according to UL 555S. Combination fire and smoke dampers shall be labeled according to UL 555 for 1-1/2-hour rating.
- C. Fusible Links: Replaceable, 165 deg F rated.
- D. Frame and Blades: 0.064-inch- thick, galvanized sheet steel.
- E. Mounting Sleeve: Factory-installed, 0.052-inch- thick, galvanized sheet steel; length to suit wall or floor application.
- F. Damper Motors: Provide for two-position action.
1. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.

2. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
3. Outdoor Motors and Motors in Outside-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
4. Electrical Connection: 115 V, single phase, 60 Hz.

2.9 DUCT SILENCERS

- A. Manufacturers:
 1. Industrial Noise Control, Inc.
 2. McGill AirFlow Corporation.
 3. Ruskin Company.
 4. Vibro-Acoustics.
- B. General Description: Factory-fabricated and -tested, round or rectangular silencers with performance characteristics and physical requirements as indicated.
- C. Fire Performance: Adhesives, sealants, packing materials, and accessory materials shall have fire ratings not exceeding 25 for flame-spread index and 50 for smoke-developed index when tested according to ASTM E 84.
- D. Rectangular Units: Fabricate casings with a minimum of 0.034-inch-thick, solid galvanized sheet metal for outer casing and 0.022-inch-thick, ASTM A 653, G90, perforated galvanized sheet metal for inner casing.
- E. Round Units:
 1. Outer Casings:
 - a. ASTM A 653, G90, galvanized sheet steel.
 - b. Up to 24 Inches in Diameter: 0.034 inch thick.
 - c. 26 through 40 Inches in Diameter: 0.040 inch thick.
 - d. 42 through 52 Inches in Diameter: 0.052 inch thick.
 - e. 54 through 60 Inches in Diameter: 0.064 inch thick.
 - f. Casings fabricated of spiral lock-seam duct may be one size thinner than that indicated.
 2. Interior Casing, Partitions, and Baffles:
 - a. ASTM A 653/A 653M, G90, galvanized sheet steel.
 - b. At least 0.034 inch thick and designed for minimum aerodynamic losses.
- F. Sheet Metal Perforations: 1/8-inch diameter for inner casing and baffle sheet metal.

- G. Fill Material: Inert and vermin-proof fibrous material, packed under not less than 5 percent compression.
 - 1. Erosion Barrier: Polymer bag enclosing fill and heat-sealed before assembly.
- H. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations.
 - 1. Do not use nuts, bolts, or sheet metal screws for unit assemblies.
 - 2. Lock form and seal or continuously weld joints.
 - 3. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
 - 4. Reinforcement: Cross or trapeze angles for rigid suspension.
- I. Source Quality Control:
 - 1. Acoustic Performance: Test according to ASTM E 477.
 - 2. Record acoustic ratings, including dynamic insertion loss and self-noise power levels with an airflow of at least 2000-fpm face velocity.
 - 3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.

2.10 TURNING VANES

- A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.
- B. Manufactured Turning Vanes: Fabricate 1-1/2-inch- wide, double-vane, curved blades of galvanized sheet steel set 3/4 inch o.c.; support with bars perpendicular to blades set 2 inches o.c.; and set into vane runners suitable for duct mounting.
 - 1. Manufacturers:
 - a. Ductmate Industries, Inc.
 - b. Duro Dyne Corp.
 - c. METALAIRE, Inc.
 - d. Ward Industries, Inc.
 - e. Sheet Metal Connectors, Inc.
- C. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

2.11 DUCT-MOUNTED ACCESS DOORS

- A. General Description: Fabricate doors airtight and suitable for duct pressure class.
- B. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel at all fire and fire/smoke dampers and where indicated. Include 1-by-1-inch butt or piano hinge and cam latches.

1. Manufacturers:
 - a. American Warming and Ventilating.
 - b. CESCO Products.
 - c. Ductmate Industries, Inc.
 - d. Flexmaster U.S.A., Inc.
 - e. Greenheck.
 - f. McGill AirFlow Corporation.
 - g. Nailor Industries Inc.
 - h. Ventfabrics, Inc.
 - i. Ward Industries, Inc.
2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Provide number of hinges and locks as follows:
 - a. Less Than 12 Inches Square: Secure with two sash locks.
 - b. Up to 18 Inches Square: Two hinges and two sash locks.
 - c. Up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
 - d. Sizes 24 by 48 Inches and Larger: One additional hinge.
- C. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1-inch thickness. Include cam latches.
 1. Manufacturers:
 - a. Flexmaster U.S.A., Inc.
 2. Frame: Galvanized sheet steel, with spin-in notched frame.
- D. Pressure Relief Access Door: Double wall and duct mounting; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated, latches, and retaining chain.
 1. Manufacturers:
 - a. American Warming and Ventilating.
 - b. CESCO Products.
 - c. Ductmate Industries, Inc.
 - d. Greenheck.
 - e. KEES, Inc.
 - f. McGill AirFlow Corporation.
 - g. Nexus PDQ.
 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

- E. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.
- F. Insulation: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.12 FLEXIBLE CONNECTORS

- A. Manufacturers:
 - 1. Duro Dyne Corp.
 - 2. Ventfabrics, Inc.
 - 3. Ward Industries, Inc.
- B. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
- C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch-wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Select metal compatible with ducts.
- D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26 oz./sq. yd.
 - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F.
- E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
 - 1. Minimum Weight: 24 oz./sq. yd.
 - 2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
 - 3. Service Temperature: Minus 50 to plus 250 deg F.
- F. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
 - 1. Minimum Weight: 16 oz./sq. yd.
 - 2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
 - 3. Service Temperature: Minus 67 to plus 500 deg F.
- G. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
 - 1. Minimum Weight: 14 oz./sq. yd.
 - 2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
 - 3. Service Temperature: Minus 67 to plus 500 deg F.

2.13 FLEXIBLE DUCTS

- A. Manufacturers:
 - 1. Ductmate Industries, Inc.

2. Flexmaster U.S.A., Inc.
 3. Hart & Cooley, Inc.
 4. McGill AirFlow Corporation.
- B. Noninsulated-Duct Connectors: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.
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.
- C. Insulated-Duct Connectors: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized 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.
- D. Flexible Duct 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.

2.14 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 APPLICATION AND INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts.
- B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- D. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff.
- E. Provide test holes at fan inlets and outlets and elsewhere as indicated.

- F. Install fire and smoke dampers, with fusible links, according to manufacturer's UL-approved written instructions.
- G. Install duct silencers rigidly to ducts.
- H. Install duct access doors to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:
 - 1. On both sides of duct coils and turning vanes.
 - 2. Downstream from volume dampers and equipment.
 - 3. Adjacent to fire or fire/smoke dampers, providing access to reset or reinstall fusible links.
 - 4. On sides of ducts where adequate clearance is available.
 - 5. Downstream of duct mounted air flow measuring stations.
- I. Install the following sizes for duct-mounting, rectangular access doors:
 - 1. One-Hand or Inspection Access: 8 by 5 inches.
 - 2. Two-Hand Access: 12 by 6 inches.
 - 3. Head and Hand Access: 18 by 10 inches.
 - 4. Head and Shoulders Access: 21 by 14 inches.
 - 5. Body Access: 25 by 14 inches.
 - 6. Body Plus Ladder Access: 25 by 17 inches.
- J. Install the following sizes for duct-mounting, round access doors:
 - 1. One-Hand or Inspection Access: 8 inches in diameter.
 - 2. Two-Hand Access: 10 inches in diameter.
 - 3. Head and Hand Access: 12 inches in diameter.
 - 4. Head and Shoulders Access: 18 inches in diameter.
 - 5. Body Access: 24 inches in diameter.
- K. Install the following sizes for duct-mounting, pressure relief access doors:
 - 1. One-Hand or Inspection Access: 7 inches in diameter.
 - 2. Two-Hand Access: 10 inches in diameter.
 - 3. Head and Hand Access: 13 inches in diameter.
 - 4. Head and Shoulders Access: 19 inches in diameter.
- L. Label access doors according to Division 23 Section "HVAC Identification."
- M. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.
- N. For fans developing static pressures of 5-inch wg and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

- O. Connect terminal units to supply ducts directly. Do not use flexible ducts.
- P. Connect diffusers or light troffer boots to low pressure ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.
- Q. Connect flexible ducts to metal ducts with draw bands.
- R. Install duct test holes where indicated and required for testing and balancing purposes.

3.2 ADJUSTING

- A. Adjust duct accessories for proper settings.
- B. Adjust fire and smoke dampers for proper action.
- C. Positioning all manual-volume dampers fully open before start of testing adjusting and balancing.

END OF SECTION 23 3300

SECTION 23 3416

CENTRIFUGAL FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes centrifugal fans.

1.3 PERFORMANCE REQUIREMENTS

- A. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
 - 1. Certified fan performance curves with system operating conditions indicated.
 - 2. Certified fan sound-power ratings.
 - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 4. Material gages and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
- 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. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.
 - 2. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
- C. Maintenance Data: For centrifugal fans to include in maintenance manuals specified in Division 1.

1.5 QUALITY ASSURANCE

- A. 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.

- B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
- C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.
- B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

- A. Coordinate size and location of structural-steel support members.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

1.8 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. Belts: One set for each belt-driven unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Aerovent; a Twin City Fan Company.
 - 2. Ammerman Company, Inc./General Resource Corp.
 - 3. Buffalo Forge Co./Howden Fan Co.
 - 4. Central Blower Co.
 - 5. Chicago Blower Corp.
 - 6. Cook, Loren Company.
 - 7. Industrial Air Division, Lau Commercial Industrial Fans/Lau Industries.
 - 8. Trane Co. (The).

2.2 MANUFACTURED UNITS

- A. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure.

2.3 HOUSINGS

- A. Materials and Fabrication: Formed and reinforced steel panels to make curved scroll housings with shaped cutoff, spun-metal inlet bell, and doors or panels to allow access to internal parts and components.
1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 2. Fabrication Class: AMCA 99, Class I, Class II, or Class III.
 3. Horizontal Flanged Split Housing: Bolted construction.
- B. Coatings: Powder-baked enamel.

2.4 WHEELS

- A. Backward-Inclined Fan Wheels: Steel construction with curved inlet flange, back plate, backward-inclined blades continuously welded to the back plate; cast-iron or cast-steel hub riveted to back plate and fastened to shaft with set screws.
- B. Forward-Curved Fan Wheels: Black-enameled or galvanized steel construction with inlet flange, back plate, shallow blades with inlet and tip curved forward in direction of airflow, mechanically secured to flange and back plate; cast-steel hub swaged to back plate and fastened to shaft with set screws.
- C. Airfoil-Fan Wheels: Steel construction with smooth-curved inlet flange; heavy back plate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and back plate; cast-iron or cast-steel hub riveted to back plate and fastened to shaft with set screws.
- D. Coatings: Powder-baked enamel.

2.5 SHAFTS

- A. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
- B. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
- C. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

2.6 BEARINGS

- A. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

1. Ball-Bearing Rating Life: ABMA 9, L_{10} of 120,000 hours.
2. Roller-Bearing Rating Life: ABMA 11, L_{10} of 120,000 hours.

2.7 BELT DRIVES

- A. Description: Factory mounted, with final alignment and belt adjustment made after installation.
 1. Service Factor Based on Fan Motor: 1.2.
- B. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
- C. 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.
- D. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 1. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements; 0.1046-inch-thick, 3/4-inch 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.
- E. Motor Mount: Adjustable for belt tensioning.

2.8 ACCESSORIES

- A. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
- B. Companion Flanges: Galvanized steel, for duct connections.

2.9 MOTORS

- A. Refer to Division 15 Section "Motors" for general requirements for factory-installed motors.
- B. Motor Construction: NEMA MG 1, general purpose, continuous duty, high efficiency, Design B.
- C. Enclosure Type: Provide where indicated
 1. Open drip proof where satisfactorily housed or remotely located during operation.
 2. Guarded drip proof where exposed to contact by employees or building occupants.

2.10 SOURCE QUALITY CONTROL

- A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300,

"Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

- B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install centrifugal fans level and plumb.
- B. Support floor-mounting units using restrained spring isolators having a static deflection of 1 inch.
 - 1. Secure vibration isolators to concrete bases using anchor bolts cast in concrete base.
- C. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."
- D. Install units with clearances for service and maintenance.
- E. Label fans according to requirements specified in Division 15 Section "Mechanical Identification."

3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 15 Section "Duct Accessories."
- B. Install ducts adjacent to fans to allow service and maintenance.
- C. Ground equipment.
- D. 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 and UL 486B.

3.3 FIELD QUALITY CONTROL

- A. Equipment Startup Checks:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 3. Verify that cleaning and adjusting are complete.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 5. Verify lubrication for bearings and other moving parts.
 6. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
- B. Starting Procedures:
1. Energize motor and adjust fan to indicated rpm.
 2. Measure and record motor voltage and amperage.
- C. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.
- D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Shut unit down and reconnect automatic temperature-control operators.
- F. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.
- G. Replace fan and motor pulleys as required to achieve design airflow.
- H. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.4 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Lubricate bearings.

3.5 CLEANING

- A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.
- B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.
 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.

2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."
3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 23 3416

SECTION 23 36 00

AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Single-duct air terminal units.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
 - 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 include the following:
 - 1. Instructions for resetting minimum and maximum air volumes.
 - 2. Instructions for adjusting software set points.

1.4 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."
- 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. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

1.5 COORDINATION

- A. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
 1. Anemostat; a Mestek Company.
 2. Carnes.
 3. Environmental Technologies, Inc.; Enviro-Air Div.
 4. Krueger.
 5. METALAIRE, Inc.; Metal Industries Inc.
 6. Nailor Industries of Texas Inc.
 7. Price Industries.
 8. Titus.
 9. Tuttle & Bailey.

2.2 SINGLE-DUCT AIR TERMINAL UNITS

- A. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal shroud.
- B. Casing: Construct casings of minimum 0.034-inch (22 gauge) steel.
 1. Casing Lining: Line inside surfaces of casings with a minimum of 1/2-inch-thick, fibrous-glass insulation; 1.5-lb/cu. ft. density with non-porous 0.001" scrim backed aluminum foil liner, complying with NFPA 90A requirements and UL 181 erosion requirements. Secure lining to prevent delamination, sagging, or settling. Discharge edges of the unit liner shall be secured with Z-shaped metal brackets along entire perimeter of opening.
 2. Casing Leakage: Construct casings such that when subjected to 0.5 in wg pressure the total leakage does not 4% of specified airflow capacity with outlet sealed and inlet wide open.
 3. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 4. Air Outlet: Rectangular S-slip and drive connections.
 5. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.

- C. Volume Damper: Galvanized steel with synthetic peripheral gasket and self-lubricating bearings. Damper shaft shall be constructed of low thermal conductive material. Shaft shall be permanently and clearly stamped on the end to indicate damper position and shall be suitable for direct mounting of damper actuator. Damper shall incorporate a mechanical stop to prevent overstroking.
 - 1. Maximum Damper Leakage: ARI 880 rated. Construct air dampers such that when subjected to 3.0 in wg inlet pressure the total leakage with damper fully closed does not exceed 1.0% of the maximum rated airflow capacity.
 - 2. Damper Position: Normally closed.
- D. Velocity Sensor: Provide multi-point, center averaging velocity sensor with a minimum of four measuring ports parallel to the take-off point from the sensor. Sensor shall provide a minimum differential pressure signal of 0.03" wg. at an inlet velocity of 500 fpm or less.
 - 1. Sensor Tubing: Pneumatic sensor tubing shall be UL listed fire retardant (FR) virgin polyethylene provided by terminal unit manufacturer. Provide brass flow measurement taps in sensor tubing for field verification of cfm by hand-held flow transducer.
 - 2. Calibration Charts: Manufacturer shall provide flow versus pressure differential chart for each terminal unit to allow for field verification of calibration.
- E. Hot-Water Heating Coil (Where scheduled): Factory installed with copper tube, mechanically expanded into heavy gauge aluminum-plate fins; leak tested underwater to 200 psig. Tubes shall have a minimum wall thickness of 0.016". Number of coil rows, circuits, and fin spacing shall be selected to meet performance requirements as indicated on the drawings and schedules.
- F. Control Panel Enclosure: NEMA 1, with access panel sealed from airflow and mounted on side of unit.
- G. DDC Controls: Electronic damper actuator, flow transducer, and control module shall be provided and field mounted by the Temperature Control Contractor. All power and control wiring shall be plenum rated.

2.3 SOURCE QUALITY CONTROL

- A. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.
- B. Verification of Performance: Rate air terminal units according to ARI 880.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to air terminal units to allow service and maintenance.
- C. Hot-Water Piping: In addition to requirements in Division 23 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.
- D. Connect ducts to air terminal units according to Division 23 Section "Metal Ductwork"

3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
 - 2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Remove and replace malfunctioning units and retest as specified above.

3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units. Refer to Division 1

END OF SECTION

SECTION 23 37 13

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.
- B. Related Sections include the following:
 - 1. Division 8 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
 - 2. Division 23 Section "Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 SUBMITTALS

- A. Product Data: For each 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.
- B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on 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.

PART 2 - PRODUCTS

2.1 DIFFUSERS REGISTERS AND GRILLES

- A. Drawings and schedules indicate specific requirements of diffusers, registers, and grilles and are based on the performance of the products listed.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
 - a. Anemostat; a Mestek Company.
 - b. Carnes.
 - c. Krueger.
 - d. METALAIRE, Inc.; Metal Industries Inc.
 - e. Nailor Industries of Texas Inc.
 - f. Price Industries.
 - g. Titus.
 - h. Tuttle & Bailey.

2.2 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 practicable. 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 23 37 13

SECTION 23 37 23

HVAC GRAVITY VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following types of roof-mounting intake and relief ventilators:
 - 1. Roof hoods
- B. Related Sections include the following:
 - 1. Division 23 Section "Power Ventilators" for roof-mounting exhaust fans.

1.3 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Intake and relief ventilators shall be capable of withstanding the effects of gravity loads, wind loads and thermal movements without permanent deformation of components, noise or metal fatigue, or permanent damage to fasteners and anchors.

1.4 SUBMITTALS

- A. Shop Drawings: For intake and relief ventilators. Include plans, elevations, sections, details and ventilator attachments to curbs and curb attachments to roof structure.
- B. Coordination Drawings: Roof framing plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1. Structural members to which roof curbs and ventilators will be attached.
 - 2. Sizes and locations of roof openings.
- C. Samples for Verification: For each type of exposed finish required for intake and relief ventilators.
- D. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain ventilators through one source from a single manufacturer where indicated to be of same type, design, or factory-applied color finish.

- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of intake and relief ventilators and are based on the specific equipment indicated. Refer to Division 1 Section “Product Requirements.”
 - 1. Do not modify intended aesthetic effects, as judged solely by Architect, except with Architect’s approval. If modifications are proposed, submit comprehensive explanatory data to Architect for review.
- C. Welding: Qualify procedures and personnel according to the following:
 - 1. AWS D1.2, “Structural Welding Code—Aluminum.”
 - 2. AWS D1.3, “Structural Welding Code—Sheet Steel.”

1.6 COORDINATION

- A. Coordinate installation of roof curbs and roof penetrations. These items are specified in Division 7 Section “Roof Accessories.”

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. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 MATERIALS

- A. Aluminum Extrusions: ASTM B 221, Alloy 6063-T5 or T52.
- B. Aluminum Sheet: ASTM B 209, Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.
- C. Galvanized-Steel Sheet: ASTM A 653, G90 zinc coating, mill phosphatized
- D. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel, unless otherwise indicated. Do not use metals that are incompatible with joined materials
 - 1. Use types and sizes to suit unit installation conditions.
 - 2. Use hex-head or Phillips panhead screws for exposed fasteners, unless otherwise indicated.
- E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.3 FABRICATION, GENERAL

- A. Factory fabricate intake and relief ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.

- B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
- C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.
- D. Fabricate supports, anchorages, and accessories required for complete assembly.
- E. Preform shop welding by AWS-certified procedures and personnel.

2.4 ROOF HOODS

- A. Available Manufacturers:
 - 1. Acme Engineering & Mfg. Corp.
 - 2. Carnes.
 - 3. Greenheck.
 - 4. Loren Cook Company.
 - 5. Penn Ventilation.
- B. Factory fabricate according to SMACNA's "HVAC Duct Construction Standards – Metal and Flexible," Figures 5-6 and 5-7.
- C. Materials: Galvanized-steel sheet, minimum 0.064-inch thick base and 0.040-inch- thick hood or Aluminum sheet, minimum 0.063-inch thick base and 0.050-inch thick hood; suitably reinforced to match hoods indicated in schedule on plans.
- D. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch- thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.
 - 1. Configuration: Built-in cant mounting flange.
 - 2. Overall Height: 8 inches 18 inches.
- E. Bird Screening: Galvanized-steel, 1/2-inch square mesh, 0.041-inch wire, 1/2-inch square mesh, 0.063-inch wire or Aluminum, 1/2-inch square mesh, 0.063-inch wire.
- F. Galvanized-Steel Sheet Finish:
 - 1. Surface Preparation: Clean surfaces of dirt, grease, and other containments. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.
 - 2. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
 - 3. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil for topcoat and an overall minimum dry film thickness of 2 mils.

- a. Color and Gloss: Manufacturers standard color as selected by the architect.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install intake and relief ventilators level, plumb, and at indicated alignment with adjacent work.
- B. Secure intake and relief ventilators to roof curbs with cadmium-plated hardware. Refer to Division 7 Section "Roof Accessories" for installation of roof curbs.
- C. Install intake and relief ventilators with clearances for service and maintenance.
- D. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- E. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Division 7 Section "Joint Sealants" for sealants applied during installation.
- F. Label intake and relief ventilators according to requirements in Division 23 Section "HVAC Identification".
- G. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.
- H. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories

3.3 ADJUSTING

- A. Adjust damper linkages for proper damper operation.

END OF SECTION 23 3723

SECTION 23 41 00

PARTICULATE AIR FILTRATION

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. Pleated panel filters.
 - 2. Rigid cell box filters.
 - 3. V-bank cell filters.
 - 4. Front- and rear-access filter frames.
 - 5. Filter gages.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.
- B. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
 - 2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
- C. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.4 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. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
 2. Comply with ASHRAE 52.1 for arrestance and ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.
- C. Comply with NFPA 90A and NFPA 90B.

1.5 COORDINATION

- A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

1.6 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. Provide one complete set(s) of filters for each filter bank. If system includes prefilters, provide only prefilters.

PART 2 - PRODUCTS

2.1 PLEATED PANEL FILTERS

- A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AAF International.
 - b. Airguard.
 - c. Camfil Farr.
 - d. Columbus Industries, Inc.
 - e. CRS Industries, Inc.; CosaTron Division.
 - f. D-Mark.
 - g. Filtration Group.
 - h. Flanders-Precisionaire.
 - i. Koch Filter Corporation.
 - j. Purafil, Inc.
 - k. Research Products Corp.
 - l. Tri-Dim Filter Corporation.
- B. Filter Unit Class: UL 900, Class 2.
- C. Media: Interlaced glass or synthetic fibers or cotton and synthetic fibers coated with nonflammable adhesive.

1. Media shall be coated with an antimicrobial agent.
 2. Separators shall be bonded to the media to maintain pleat configuration.
 3. Welded wire grid shall be on downstream side to maintain pleat.
 4. Media shall be bonded to frame to prevent air bypass.
 5. Support members on upstream and downstream sides to maintain pleat spacing.
- D. Filter-Media Frame: Cardboard frame with perforated metal retainer with metal grid on outlet side and steel rod grid on inlet side, hinged, with pull and retaining handles sealed or bonded to the media.
- E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
- F. Capacities and Characteristics: As scheduled on drawings.

2.2 RIGID CELL BOX FILTERS

- A. Description: Factory-fabricated, adhesive-coated, disposable, packaged air filters with media perpendicular to airflow, and with holding frames.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AAF International.
 - b. Airguard.
 - c. Camfil Farr.
 - d. Columbus Industries, Inc.
 - e. CRS Industries, Inc.; CosaTron Division.
 - f. D-Mark.
 - g. Filtration Group.
 - h. Flanders-Precisionaire.
 - i. Koch Filter Corporation.
 - j. Purafil, Inc.
 - k. Research Products Corp.
 - l. Tri-Dim Filter Corporation.
- B. Filter Unit Class: UL 900, Class 2.
- C. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.
1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 2. Media shall be coated with an antimicrobial agent.
- D. Filter-Media Frames: Galvanized steel.

- E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
- F. Capacities and Characteristics: As scheduled on drawings.

2.3 V-BANK CELL FILTERS

- A. Description: Factory-fabricated, disposable, packaged air filters with media angled to airflow, and with holding frames.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AAF International.
 - b. Airguard.
 - c. Camfil Farr.
 - d. Columbus Industries, Inc.
 - e. CRS Industries, Inc.; CosaTron Division.
 - f. D-Mark.
 - g. Filtration Group.
 - h. Flanders-Precisionaire.
 - i. Koch Filter Corporation.
 - j. Purafil, Inc.
 - k. Research Products Corp.
 - l. Tri-Dim Filter Corporation.
- B. Filter Unit Class: UL 900, Class 2
- C. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.
 - 1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2. Media shall be coated with an antimicrobial agent.
- D. Filter-Media Frames: Galvanized steel.
- E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
- F. Capacities and Characteristics: As scheduled on drawings.

2.4 FRONT- AND REAR-ACCESS FILTER FRAMES

- A. Framing System: Galvanized-steel framing members with access for either upstream (front) or downstream (rear) filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AAF International.
 - b. Airguard.
 - c. Camfil Farr.
 - d. Columbus Industries, Inc.
 - e. CRS Industries, Inc.; CosaTron Division.
 - f. D-Mark.
 - g. Filtration Group.
 - h. Flanders-Precisionaire.
 - i. Koch Filter Corporation.
 - j. Purafil, Inc.
 - k. Research Products Corp.
- B. Prefilters: Incorporate a separate track with spring clips, removable from front or back.
- C. Sealing: Factory-installed, positive-sealing device for each row of filters, to ensure seal between gasketed filter elements and to prevent bypass of unfiltered air.

2.5 FILTER GAGES

- A. Diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Airguard.
 - b. Dwyer Instruments, Inc.
 2. Diameter: 4-1/2 inches.
 3. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg or Less: 0- to 0.5-inch wg.
 4. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg or Less: 0- to 1.0-inch wg.
 5. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg or Less: 0- to 2.0-inch wg.
 6. Scale Range for Filter Media Having a Recommended Final Resistance of 2.0- to 3.0-Inch wg or Less: 0- to 3.0-inch wg.
 7. Scale Range for Filter Media Having a Recommended Final Resistance of 3.0- to 4.0-Inch wg or Less: 0- to 4.0-inch wg.
- B. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
- B. Install filters in position to prevent passage of unfiltered air.
- C. Install filter gage for each filter bank.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.
- E. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.
- F. Coordinate filter installations with duct and air-handling-unit installations.

3.2 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. Test for leakage of unfiltered air while system is operating.
- D. Air filter will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.3 CLEANING

- A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 234100

SECTION 23 57 00

HEAT EXCHANGERS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes shell-and-tube heat exchangers and plate heat exchangers for HVAC applications.

1.3 SUBMITTALS

- A. Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories for each type of product indicated. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
- B. Maintenance Data: For heat exchangers to include in operation and maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, performance, and dimensional requirements of heat exchangers and are based on the specific equipment indicated. Other manufacturers' products with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions Procedures."
- B. ASME Compliance: Fabricate and permanently label heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Shell-and-Tube Heat Exchangers:
 - a. ITT Fluid Handling; Div. of ITT Fluid Technology Corp.
 - b. Engineer approved equal.

2.2 SHELL-AND-TUBE HEAT EXCHANGERS

- A. Configuration: Two pass, U-tube.

- B. Shell and Head Materials: Steel shell and fabricated-steel head.
- C. Tube and Tube Sheet Materials: Seamless, 3/4-inch OD copper tubes with steel tube sheets.
- D. Piping Connections: Flanged-shell fluid entry and threaded-shell fluid exit. Flanged-head ports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 HEAT EXCHANGER INSTALLATION

- A. Install heat exchangers according to manufacturer's written instructions.
- B. Install shell-and-tube heat exchangers on saddle supports with provisions to drain shell.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Maintain manufacturer's recommended clearances for service and maintenance. Install piping connections to allow service and maintenance of heat exchangers.
- C. Install piping with threaded or flanged connections at heat exchangers.
- D. Install shutoff valves at heat exchanger inlet and outlet connections.
- E. Install relief valves on heat exchanger heated-fluid connection.
- F. Install vacuum breaker at heat exchanger steam inlet connection.

3.4 CLEANING

- A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.5 COMMISSIONING

- A. Verify that heat exchangers are installed and connected according to the Contract Documents.
- B. Adjust flows and controls to deliver specified performance.
- C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain heat exchangers as specified below:
1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining heat exchangers.
 2. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
 3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 23 5700

SECTION 23 7314

FACTORY CUSTOM AIR HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes constant and variable volume, modular air-handling units with coils for indoor installations.
- B. Related Sections include the following:
 - 1. Division 23 Section "HVAC Identification" for labeling and identifying factory custom air handling units.
 - 2. Division 23 Section "HVAC Instrumentation and Controls" for temperature-control valves and sensors.
 - 3. Division 23 Section "Testing, Adjusting, and Balancing" for air balancing and final adjusting of variable speed drives and control dampers.
 - 4. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation bases.
 - 5. Division 26 Section "Variable-Frequency Motor Controllers."
 - 6. Division 26 Section "Enclosed Switches and Circuit Breakers" for factory-installed disconnect switches.

1.3 SUBMITTALS

- A. Product Data: For each type of factory custom air-handling unit indicated. Include the following:
 - 1. Certified fan-performance curves with system operating conditions indicated.
 - 2. Certified fan-sound power ratings for both air handling unit inlet, outlet and radiated at rated capacity. If unit exceeds sound power levels at scheduled conditions, manufacturer must provide sound attenuators and meet specified BHP.
 - 3. Certified coil-performance ratings with system operating conditions indicated.
 - 4. Motor ratings, electrical characteristics, and motor and fan accessories.
 - 5. Material gages and finishes.
 - 6. Filters with performance characteristics.
 - 7. Dampers, including housings, linkages, and operators.
- B. Coordination Drawings: Submit with Shop Drawings. Show mechanical-room layout and 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.

- C. Field Quality-Control Test Reports: From manufacturer.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain factory custom air-handling units through one source from a single manufacturer.
- 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. NFPA Compliance: Factory custom air-handling units and components shall be designed, fabricated, and installed in compliance with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
- D. ARI Certification: Factory custom air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.
- E. Comply with NFPA 70.

1.5 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 "Cast In Place Concrete."
- B. Coordinate size and location of structural-steel support members.

1.6 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. Filters: One set of pre and final filters for each factory custom air-handling unit.
 - 2. Fan Belts: One set for each factory custom air-handling unit fan.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Haakon.
 - 2. CES Group Inc.; Governair, Mammoth, Temtrol, Venmar Ventrol, Webco Divisions.

2.2 MANUFACTURED UNITS

- A. Factory custom air-handling units shall be factory assembled and consist of fans, motor and drive assembly, coils, damper, plenums, filters, condensate pans, blenders, mixing dampers, and accessories.

2.3 CABINET

- A. Materials: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed with low VOC content sealant.
1. Outside Casing: Galvanized steel, 16 gauge
 2. Inside Casing (Fan sections only): Perforated galvanized steel, 22 gauge.
 3. Inside Casing (Cooling coil and Humidifier sections): Stainless steel, 22 gauge.
 4. Inside Casing (All other sections): Galvanized steel, 22 gauge
 5. Floor Plate: 12 gauge epoxy coated steel or aluminum checker plate. Provide a 1.5" perimeter collar around the entire unit, and around each floor opening to ensure the unit is internally watertight. The entire base shall act as an auxiliary drain pan and hold up to 1.5" of water.
 6. Base Channel: Units shall be constructed from structural steel C-channel iron around the perimeter of the unit, with intermediate channel and angle iron supports.
 7. Lifting Lugs: Base shall be provided with lifting lugs, minimum four (4) per unit section.
 8. Test Ports: Provide 1" diameter test ports for unit air stream testing in each plenum section between each component within the AHU. Test ports shall have a tube that extends between the inside and outside of the unit and a screwed cap on the exterior to allow access. The test ports shall have been flanged on the exterior to allow air seal and shall be flanged on the interior to cover the penetration of the casing.
- B. Performance: Comply with the following.
1. Panel Deflection: Stiffeners of angle steel shall be supplied as required to maintain casing deflection criteria of 1/200 at 1.5 times the working pressure. If panels cannot meet this deflection, add additional internal reinforcing.
 2. Floor Deflection: Maximum floor deflection shall be ¼" on 240" unsupported span.
 3. Casing Leakage: Unit manufacturer shall factory pressure test each air handling unit to ensure the leakage rate of the casing does not exceed 1.0% of the unit air flow at 1.5 times the rated static pressure. (Leakage test shall be performed with all VFD and humidifier panels installed, all electrical gear installed, and all coil penetrations made).
 4. Thermal: Provide factory thermo-graphic scanning by encapsulating the AHU with an internal heat source. All insulation related cold spots shall be repaired prior to shipment. Air handling unit specific thermo-graphic data shall be provided to the U of M.
 5. Acoustical: The housing shall have been tested for acoustical performance by an independent laboratory that is accredited.
 - a. Test methods and facilities used to establish sound transmission loss values shall conform explicitly with the ASTM designation E90-85 and E413-73.
 - b. Sound Transmission Loss DB ASTM E-90 & E413-73

	1	2	3	4	5	6	7	8	
4" Walls	20	20	28	41	51	56	55	57	STC=40

c. Test methods and facilities used to establish sound absorption values shall conform explicitly with the requirements of the ASTM Standard Test Method for Sound Absorption Coefficients by the Reverberation Method: ASTM C423-84A and E795-83.

d. Sound Absorption ASTM C423-84A & E795-83

	1	2	3	4	5	6	7	8	
4" Walls	.40	.65	1.38	1.28	1.09	1.05	1.02	1.02	STC=40

6.

C. Cabinet Insulation: Comply with NFPA 90A or NFPA 90B.

1. Materials: ASTM C 1071 with coated surface exposed to airstream to prevent erosion of glass fibers.
2. Thickness: 4 inch.
3. Density: 3 lb/ cu ft
4. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
5. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50, when tested according to ASTM C 411.
6. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and ASTM C 916.
7. Mechanical Fasteners: Steel to match panel material, suitable for adhesive attachment, mechanical attachment, or welding attachment to panel without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet. All permanently joined flanged panel surfaces shall be sealed with an individual strip of 1/8" x 3/8" tape sealer.
8. Location and Application: Encased between outside and inside casing. The base shall be insulated with 3" fiberglass insulation and sheeted with a 22 gauge galvanized steel liner
9. Interior Liner: In sections where the inner wall is perforated, provide a 4 mil polyvinyl fluoride (Tedlar) liner between the inner wall and the insulation to seal the insulation.

D. Access Doors: Provide access doors between each component. Access doors shall be manufactured from 16 gauge galvanized steel. The doors shall be double wall construction with 22 gauge solid metal liner on the inside. Corners of the doors shall be continuously welded for rigidity. Four inch 3 lb/cu ft. density insulation shall be sandwiched between the 16 gauge outer layer and the 22 gauge inner layer. Doors must be the same thickness as the unit casing to maximize thermal and acoustical resistance.

1. A 12" round hermetically sealed Double Glazed Laminated glass window shall be provided in each door.
2. Hinges shall be continuous piano type stainless steel.

3. Two chrome plated "Ventlok" Model #310 high pressure latches operable from either side of the door shall be provided. Door opening shall be fully gasketed with continuous 1/2" closed cell hollow round black gasket with a metal encapsulated reinforcing backing that mechanically fastens to the door frame.
 4. Door frames shall be made from 16 gauge galvanized steel with the outside size of the door flush with the unit. Minimum door opening size shall be 18" x 70" (where height permits).
 5. Fan compartments must have a door of minimum width to remove the motor.
 6. All access doors must swing against the air pressure (i.e. positive pressure plenum doors must swing in).
- E. Lights: Marine lights with protective cast metal cage and glass globes complete with duplex receptacles shall be installed on the wall across from the access doors. A single switch with an indicator light shall be installed on the unit. All electrical wiring shall be done at the factory, and shall be installed in EMT conduit. Electrical power shall be 120V/1/60.
- F. Auxiliary Drains: Provide auxiliary 1.25" drains in fan sections downstream of cooling coils, humidifier sections, and in mixing sections. All drain connections on floor mounted air handling units shall terminate at the side of the unit.
- G. Condensate Drain Pans: Formed sections of stainless-steel sheet complying with requirements in ASHRAE 62. Fabricate pans with slopes at least 1/8" /ft. in two planes to collect condensate from cooling coils (including coil piping connections and return bends) when units are operating at maximum catalogued face velocity across cooling coil. Drain pans under normal operation shall have no standing condensate in the pans.
1. Drain Connections: Same side as access door.
 2. Units with stacked coils shall have an intermediate drain pan to collect condensate each top coil. Provide condensate drain piping extended down to the primary drain pan.

2.4 FAN SECTION

- A. Fan-Section Construction: Belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure and equipped with formed-steel channel base for integral mounting of fan, motor, and casing panels.
- B. Mount fan with vibration isolation per Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
- C. Centrifugal Fan Housings: Formed- and reinforced-steel panels to make curved scroll housings with shaped cutoff, spun-metal inlet bell, and access doors or panels to allow entry to internal parts and components.
1. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 2. Performance Class: AMCA 99-2408, Class I, II, or III as required to meet fan performance. All fans shall be tested in accordance with AMCA Standards 210-70 and 310 Test Codes for Air Moving Devices. Backward inclined fans shall bear the AMCA sticker for both air and sound performance.
 3. Horizontal Flanged Split Housing: Bolted construction.

4. Plug Fans: With steel cabinet. Fabricate without fan scroll and volute housing.
- D. Fan Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower.
- E. Backward-Inclined Fan Wheels: Steel construction with curved inlet flange, backplate, backward-inclined blades.
- F. Airfoil-Fan Wheels: Steel construction with smooth-curved inlet flange, heavy backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.
- G. Shafts: Statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
 1. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
 2. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
- H. Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with a L_{10} life of 200,000 hours according to ABMA 9.
- I. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation and with 1.5 service factor based on fan motor.
 1. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 2. Motor Pulleys: Adjustable pitch for use with 3-hp motors and smaller; fixed pitch for use with motors larger than 3 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 3. Belts: Synchronous, oil resistant, nonsparking, and nonstatic; matched for multiple belt drives.
 4. Belt Guards: Fabricate to OSHA/SMACNA requirements; 0.1046-inch-thick, 3/4-inch diamond-mesh wire screen welded to steel angle frame or equivalent; prime coated. Belt guard shall be sized to allow sheave to be increased by two sizes. Provide hinged access cover to allow for inspecting the belts without removing the fan guard.
 5. Fan Guards: Plenum fan assembly must have an enclosed safety screen as per OSHA Standards.
 6. Fan Inlet Guards: Fans shall have OSHA approved inlet screens.
 7. Motor Mount: Adjustable for belt tensioning.
- J. Airflow Measuring Probes: (SUP-003, RET-003, SUP-004, RET-004)
 1. Provide on each fan air flow measuring probes capable of continuously monitoring the air handling capacity of the respective scrolled or plenum fan.
 2. Each airflow probe shall contain multiple, averaged velocity pressure taps located symmetrically around the throat of the fan inlet and a single static pressure tap located on the fan housing. The entire airflow monitoring probe must be located outside the inlet throat as to not obstruct airflow.

3. The probes shall be capable of producing steady, non-pulsating signal of the velocity pressure, independent of the upstream static pressure without adversely affecting the performance of the fan. The sensing probes shall be accurate $\pm 3\%$ of actual fan airflow.
- K. Airflow Display: Provide on supply and return fans, a method of displaying digitally, in real time, the fans current air flow. (SUP-003, RET-003, SUP-004, RET-004)
1. The display shall be capable of showing the airflow of two (2) independent fans simultaneously.
 2. For interaction with a controller, the display shall output one (1) 0-10VDC signal for each fan being monitored.
 3. The output signal shall be accurate to $\pm 0.5\%$ of Natural Span, including non-linearity, hysteresis and non-repeatability.
- L. Sound Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.
- M. Factory test fan performance for flow rate, pressure, power, air density, rotation speed, and efficiency. Establish ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

2.5 MOTORS

- A. General: Refer to Division 23 Section "HVAC Motors" for general requirements.
- B. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
- C. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range.
- D. Temperature Rating: 50 deg C maximum temperature rise at 40 deg C ambient for continuous duty at full load (Class A Insulation).
- E. Service Factor: 1.15 for polyphase motors and 1.35 for single-phase motors.
- F. Motor Construction: Heavy duty, Design B.
- G. Bearings: The following features are required:
1. Ball or roller bearings with inner and outer shaft seals.
 2. Grease lubricated.
 3. Designed to resist thrust loading where belt or other drives produce lateral or axial thrust in motor.
- H. Enclosure Type: Totally enclosed, fan cooled (TEFC).
- I. Overload Protection: Built-in, automatically resetting, thermal-overload protection.
- J. Noise Rating: Quiet.
- K. Efficiency: NEMA Premium (TM) efficient motors as defined in NEMA MG 1 2006.
- L. Nameplate: Indicate ratings, characteristics, construction, special features, and full identification of manufacturer.

- M. Motors used with variable frequency drives shall be provided with motor shaft grounding devices, a minimum insulation class of F, and shall meet NEMA MG1 Part 31.
- N. Starters, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.

2.6 CHILLED WATER COILS

- A. Coil Sections: Common or individual, insulated, stainless steel casings. Design and construct to facilitate removal and replacement of coil for maintenance and to assure full airflow through coils. Provide blank-off panels to permit less than 1% air flow bypass around the cooling coils.
- B. Coil Construction: Rigidly supported across full face, pitched to allow drainage. Drainable and cleanable coil fabricated to ARI 410 with individual threaded plugs and return headers.
 - 1. Fins: Aluminum, mechanically bonded to tubes, fin spacing as required to meet performance requirements scheduled on drawings.
 - 2. Tubes: Seamless copper complying with ASTM B 75. Tube diameter and row number as required to meet performance requirements.
 - 3. Coil Casing: Stainless steel channel frame. Minimum 0.0625 inch (16 gauge)
 - 4. Inlet and outlet headers: Cast iron with cleaning plugs, drain and air vent tapplings for drain valve and air vent, with threaded piping connections on same end.
 - 5. Coil Racks: Coils shall be fully enclosed within casing and cooling coils shall be on mounted 304 stainless steel angle racks manufactured to allow coils to slide out individually.
- C. Coil-Performance Tests: Factory-test cooling and heating coils, except sprayed surface coils for rating according to ARI 410, "Forced-Circulation Air-Cooling and Air-Heating Coils."
 - 1. Working Pressure Ratings: 200 psig, 325 deg F.
- D. Source Quality Control: Test to 300 psig, and to 200 psig underwater.

2.7 HEATING AND ENERGY RECOVERY WATER COILS

- A. Coil Sections: Common or individual, insulated, galvanized steel casings. Design and construct to facilitate removal and replacement of coil for maintenance and to assure full airflow through coils. Provide blank-off panels to permit less than 1% air flow bypass around the heating coils.
- B. Coil Construction: Rigidly supported across full face, pitched to allow drainage. Drainable and cleanable coil fabricated to ARI 410 with individual threaded plugs and return headers.
 - 1. Fins: Aluminum, mechanically bonded to tubes, fin spacing as required to meet performance requirements scheduled on drawings.
 - 2. Tubes: Seamless copper complying with ASTM B 75. Tube diameter and row number as required to meet performance requirements scheduled on drawings.
 - 3. Coil Casing: Galvanized-steel channel frame. Minimum 0.0625 inch (16 gauge)

4. Inlet and outlet headers: Cast iron with cleaning plugs, drain and air vent tappings for drain valve and air vent, with threaded piping connections on same end.
 5. Coil Racks: Coils shall be fully enclosed within casing and heating coils shall be mounted on galvanized angle racks manufactured to allow coils to slide out individually.
- C. Coil-Performance Tests: Factory-test cooling and heating coils, except sprayed surface coils for rating according to ARI 410, "Forced-Circulation Air-Cooling and Air-Heating Coils."
1. Working Pressure Ratings: 200 psig, 325 deg F.
- D. Source Quality Control: Test to 300 psig, and to 200 psig underwater.

2.8 AIR BLENDER SECTION

- A. Provide static air blenders where shown on drawings to enhance the mixing of outside air with return air. Air mixer models shall be geometrically scaled to ensure proper performance across the full range of sizes.
- B. Static air blenders shall be constructed of 0.125" thick welded aluminum and shall have bare aluminum finish.
- C. Furnish and install factory built and factory tested air blenders in accordance with the manufacturers written installation instructions and SMACNA plenum construction guidelines. Provide reinforcing in plenum where the mixing is installed to eliminate excess vibration or deflection of blender or unit housing.

2.9 DAMPERS

- A. General: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at 2000-fpm face velocity through damper and 4-inch wg pressure differential.
- B. Factory Mounted Dampers: Internal return air dampers and energy recovery coil face dampers shall be furnished with the air handling unit and mounted at the factory.
 1. Performance: Double-skin, airfoil-blade galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals, in opposed-blade arrangement with steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. at 1-inch wg.
- C. Dampers: Outside air and relief dampers for Factory Custom Air Handling Units shall be mounted externally to the unit. Refer to Division 23 Section "HVAC Instrumentation and Controls for damper specifications.
- D. Damper Operators: Electronic specified in Division 23 Section "HVAC Instrumentation and Controls."

2.10 FILTER SECTION

- A. Filters: Comply with NFPA 90A.

- B. Filter Section: Provide filter holding frames arranged for flat orientation. Filters shall be removable from the upstream side of the rack face. Side access filter racks are not acceptable.
- C. Disposable Panel Filters: Factory-fabricated, viscous-coated, flat-panel-type, disposable air filters with holding frames.
 - 1. Media: Interlaced glass fibers sprayed with nonflammable adhesive.
 - 2. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.
 - 3. Duct-Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.
- D. Extended-Surface, Disposable Panel Filters: Factory-fabricated, dry, extended-surface filters with holding frames.
 - 1. Media: Fibrous material formed into deep-V-shaped pleats and held by self-supporting wire grid.
 - 2. Media and Media-Grid Frame: Galvanized steel.
 - 3. Duct-Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Concrete Bases: Install floor mounting units on 4-inch- high concrete bases. See Division 23 Section "HVAC Materials and Methods" for concrete base materials and fabrication requirements.
- B. Equipment Mounting: Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
- C. Arrange installation of units to provide access space around factory custom air-handling units for service and maintenance.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to factory custom air-handling units mounted on vibration isolators with flexible connectors.

- D. Connect condensate drain pans using NPS 1-1/4, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Connect to supply and return coil tapplings with shutoff or balancing valve and union or flange at each connection.
- F. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connections.
- G. Electrical: Comply with applicable requirements in Division 26 Sections for power wiring, switches, and motor controls.
- H. Ground equipment according to Division 26 Section "Grounding and Bonding."
- I. 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 and UL 486B.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to witness contractor inspections of field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
 - 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. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Final Checks before Startup: Contractor to perform the following startup checklist prior to start-up by factory authorized service representative.
 - 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. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
 - 6. Set bypass dampers to full face flow.

7. Set outside- and return-air mixing dampers to minimum outside-air setting.
 8. Comb coil fins for parallel orientation.
 9. Install clean filters.
 10. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
- C. Starting procedures for factory custom air-handling units include the following:
1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
 2. Measure and record motor electrical values for voltage and amperage.
 3. Manually operate dampers from fully closed to fully open position and record fan performance.
- D. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for factory custom air-handling system testing, adjusting, and balancing.

3.6 ADJUSTING

- A. Adjust damper linkages for proper damper operation.

3.7 CLEANING

- A. Clean factory custom air-handling 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 and testing, adjusting, and balancing factory custom air-handling and air-distribution systems, clean filter housings and install new filters.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain factory custom air-handling units. Refer to Division 1.

END OF SECTION 23 7314

SECTION 23 81 23

COMPUTER-ROOM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Floor-mounted computer-room air conditioners, 6 tons and larger.
 - 2. Ceiling-mounted computer-room air conditioners.

1.3 DEFINITION

- A. BAS: Building automation system.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For computer-room air conditioners. 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. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.
- D. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from Installers of the items involved.
- E. Field quality-control reports.
- F. Operation and Maintenance Data: For computer-room air conditioners to include in emergency, operation, and maintenance manuals.
- G. Warranty: Sample of special warranty.

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. 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 62.1-2004, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."
- C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004.
- D. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

1.6 COORDINATION

- A. Coordinate layout and installation of computer-room air conditioners and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
- B. Coordinate installation of computer-room air conditioners with computer-room access flooring Installer.
- C. Coordinate sizes and locations of concrete bases with actual equipment provided.
- D. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Humidifiers: Manufacturer's standard, but not less than three years from date of Substantial Completion.
 - 2. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

1.8 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. Fan Belts: One set(s) for each belt-driven fan.
 - 2. Filters: One set(s) of filters for each unit.

PART 2 - PRODUCTS

2.1 FLOOR-MOUNTED UNITS 6 TONS AND LARGER

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Data Aire Inc.
 2. Liebert Corporation.
- B. Description: Packaged, factory assembled, prewired, and prepiped; consisting of cabinet, fans, filters, humidifier, and controls.
- C. Cabinet and Frame: Welded steel, braced for rigidity, and supporting compressors and other mechanical equipment and fittings.
1. Doors and Access Panels: Galvanized steel with polyurethane gaskets, hinges, and concealed fastening devices.
 2. Insulation: Thermally and acoustically insulate cabinet interior with 1-inch thick duct liner.
 3. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
 4. Finish of Exterior Surfaces: Baked-on, textured vinyl enamel; color as selected from manufacturer's standard colors.
 5. Floor Stand: Welded tubular steel, 12" high, with adjustable legs and vibration isolation pads.
- D. Supply-Air Fan(s):
1. Double-inlet, forward-curved centrifugal fan(s); statically and dynamically balanced.
 2. Drive: V-belt, with steel shaft with self-aligning ball bearings and cast-iron or steel sheaves, variable- and adjustable-pitch motor sheave, minimum of two matched belts, with drive rated at a minimum of two times the nameplate rating of motor.
- E. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating two-way control valve.
1. Cooling Medium: Water.
 2. Control Valve: Class 125 body.
 - a. Maximum Pressure Drop: 3 psig at design flow rate.
 - b. Close-Off (Differential) Pressure Rating: 100 percent of pressure differential across valve or 100 percent of total system (pump) head.
 3. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1-2004 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.

- F. Electric-Resistance Heating Coil: Enclosed finned-tube electric elements arranged for minimum of three stages, with thermal safety switches, manual-reset overload protection, and branch-circuit overcurrent protection.
- G. Extended-Surface, Disposable, Panel Filter: Pleated, lofted, nonwoven, reinforced cotton fabric; supported and bonded to welded-wire grid; enclosed in cardboard frame..
 - 1. Thickness: 4 inches.
 - 2. Initial Resistance: 0.35 inches wg.
 - 3. Recommended Final Resistance: 1.0 inches wg.
 - 4. Arrestance (ASHRAE 52.1): 90
 - 5. Merv (ASHRAE 52.2): 7
- H. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders, and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.
 - 1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
 - 2. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
 - 3. Drain Cycle: Field-adjustable drain duration and drain interval.
- I. Integral Electrical Controls: Unit-mounted electrical enclosure with piano-hinged door, grounding lug, combination magnetic starters with overload relays, circuit breakers and cover interlock, and fusible control-circuit transformer.
- J. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- K. Electronic-Control System: Solid state, with start button, stop button, temporary loss of power indicator, manual-reset circuit breakers, temperature control, humidity control, and monitor panel.
 - 1. Monitor Panel: Backlighted, with no visible indicator lights until operating function is activated; indicators include cooling, humidification, loss of airflow, change filters, high temperature, low temperature, high humidity, low humidity, high head pressure (each compressor), and low suction pressure (each compressor).
 - 2. Temperature- and Humidity-Control Modules: Solid state, plug-in; with adjustable set point, push-to-test calibration check button, and built-in visual indicators to show mode of operation.
 - 3. Location: Behind hinged door in front of unit; isolated from conditioned airstream to allow service while system is operating.
- L. Microprocessor-Control System: Continuously monitors operation of process cooling system; continuously displays room temperature and room relative humidity; sounds

alarm on system malfunction and simultaneously displays problem. If more than one malfunction occurs, system displays fault in sequence with room temperature and continues to display fault when malfunction is cleared until system is reset.

1. Malfunctions:
 - a. Power loss.
 - b. Loss of airflow.
 - c. Clogged air filter.
 - d. High room temperature.
 - e. Low room temperature.
 - f. High humidity.
 - g. Low humidity.
 - h. Smoke/fire.
 - i. Water under floor.
 - j. Supply fan overload.
2. Digital Display:
 - a. Control power on.
 - b. Humidifying.
 - c. Dehumidifying.
 - d. Heat operating.
3. Push buttons shall stop and start process cooling system, silence audible alarm, test indicators, and display room's relative humidity.
4. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display unit status and alarms.
 - a. ASHRAE 135 (BACnet) communication interface with the BAS shall enable the BAS operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel shall be available through the BAS.

2.2 CEILING-MOUNTED UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Data Aire Inc.
 2. Liebert Corporation.
- B. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for horizontal ceiling mounting.

- C. Cabinet: Galvanized steel with baked-enamel finish, insulated with 1/2-inch-thick duct liner.
 - 1. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
- D. Supply-Air Fan: Forward curved, centrifugal, and directly driven by two-speed motor.
- E. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with two-way control valve.
 - 1. Cooling Medium: Water.
 - 2. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1-2004 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.
- F. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor, dehumidification relay, and high-temperature-limit switches.
- G. Filter: 1-inch-thick, disposable, glass-fiber media.
 - 1. Initial Resistance: 0.35 inches wg.
 - 2. Recommended Final Resistance: 1.00 inches wg.
 - 3. Arrestance (ASHRAE 52.1): 90 percent.
 - 4. Merv (ASHRAE 52.2): 7.
- H. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders, and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.
 - 1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
 - 2. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
 - 3. Drain Cycle: Field-adjustable drain duration and drain interval.
- I. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- J. Control System: Unit-mounted panel with main fan contactor, compressor contactor, compressor start capacitor, control transformer with circuit breaker, solid-state temperature-and humidity-control modules, humidity contactor, time-delay relay, heating contactor, and high-temperature thermostat. Provide solid-state, wall-mounted control panel with start-stop switch, adjustable humidity set point, and adjustable temperature set point.

2.3 FAN MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

2.4 CAPACITIES AND CHARACTERISTICS

- A. Refer to Schedules on Drawings.

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 roughing-in for hydronic piping systems to verify actual locations of piping connections before equipment installation.
- C. Examine walls, floors, and roofs for suitable conditions where computer-room air conditioners will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances.
- B. Computer-Room Air-Conditioner Mounting: Install using elastomeric mounts. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
 - 1. Minimum Deflection: 1/4 inch.
- C. Suspended Computer-Room Air Conditioners: Install using continuous-thread hanger rods and spring hangers of size required to support weight of computer-room air conditioner.
 - 1. Comply with requirements for hangers and supports specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

- B. Install piping adjacent to machine to allow service and maintenance.
- C. Water and Drainage Connections: Comply with applicable requirements in Division 22 Section "Domestic Water Piping." Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.
- D. Chilled-Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Provide shutoff valves in water inlet and outlet piping on water-cooled units.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 - 1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
 - 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. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.
- F. After startup service and performance test, change filters and flush humidifier.

3.5 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.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

END OF SECTION 238123

SECTION 23 82 39

UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes:
 - 1. Cabinet Unit Heaters.
 - 2. Propeller Unit Heaters.

1.3 SUBMITTALS

- A. Product Data: Include specialties and accessories for each unit type and configuration.
- B. Shop Drawings: Submit the following for each unit type and configuration:
 - 1. Plans, elevations, sections, and details.
 - 2. Details of anchorages and attachments to structure and to supported equipment.
 - 3. Power, signal, and control wiring diagrams. Differentiate between manufacturer-installed and field-installed wiring.
 - 4. Equipment schedules to include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

1.4 QUALITY ASSURANCE

- A. 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.

1.5 COORDINATION

- A. Coordinate layout and installation of cabinet unit heaters and suspension system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

1.6 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. Cabinet Unit Heater Filters: Furnish 1 spare filter for each filter installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cabinet Unit Heaters:
 - a. Dunham-Bush, Inc.
 - b. Sterling.
 - c. McQuay International.
 - d. Trane Company (The); North American Commercial Group.
 - 2. Propeller Unit Heaters
 - a. Airthbam Manufacgturing Company
 - b. Dunham-Bush, Inc.
 - c. Sterlung
 - d. McQuay International
 - e. Trane Company (The);
 - f. North American Commercial Group

2.2 CABINET UNIT HEATERS

- A. Description: An assembly including cabinet, filter, chassis, coil, fan, controls, and motor in blow-through configuration with heating coil.
- B. Chassis: Galvanized steel, with flanged edges and unit-leveling bolts.
- C. Coil Section Insulation: 1-inch duct liner complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
 - 1. Fire-Hazard Classification: Duct liner and adhesive shall have a maximum flame-spread rating of 25 and smoke-developed rating of 50 when tested according to ASTM E 84.
- D. Cabinet: Galvanized steel, with removable face plate panel fastened with tamperproof fasteners, and control access panel with vandal resistant lock.
- E. Cabinet Finish: Flush wall plate bonderize, phosphatize, and flow-coat with baked-on primer with manufacturer's standard paint, in color selected by Architect, applied to factory-assembled and -tested cabinet unit heater before shipping.
- F. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and with manual air vent. Coils shall be rated for a minimum working pressure of 300 psig and a maximum entering water temperature of 275 deg F, with manual air vent.

- G. Fan: DWDI forwardly curved, centrifugal type. Fan housing shall be fabricated of heavy galvanized steel and of two-piece construction with removable front half for complete access to fans.
- H. Fan Motors: 115/60/1 PSC single speed, sleeve bearing motors with oilers, inherent thermal overload protection with automatic reset and resilient mounts and designed for use with a solid-state variable speed controller
 - 1. Provide factory mounted starter-disconnect.
 - 2. Speed Controller- units shall have a solid-state variable speed controller with integral “on-off” switch which shall provide inform unlimited fan speed from high to low. It shall include an RFI filter circuit.
- I. Accessories: Provide the following accessories:
 - 1. Aluminum wall boxes with integral eliminators and insect screen.
 - 2. Steel subbase, height as indicated.
 - 3. Plastic motor-oiler tubes extending to beneath top discharge grille.
 - 4. Steel recessing flanges for recessing cabinet unit heaters into wall.
 - 5. Filters: 1-inch- thick, glass-fiber media in fiberboard frame
- J. Unit Controls: Unit controls to be provided by others.
- K. Source Quality Control: Test cabinet unit heater coils according to ASHRAE 33.

2.3 CABINET UNIT HEATERS

- A. Description: An assembly including casing, coil, fan, and motor in horizontal discharge configuration with horizontal, adjustable louvers in blow-through configuration.
- B. Casing: Galvanized steel, with removable panels.
- C. Cabinet Finish: Bonderize, phosphatize, and flow-coat with baked-on primer and manufacturer's standard paint applied to factory-assembled and -tested propeller unit heater before shipping.
- D. Hot-Water Coil: Copper tube, 0.031-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering water temperature of 325 deg F, with manual air vent. Test for leaks to 375 psig underwater.
- E. Fan: Propeller with aluminum blades directly connected to motor.
- F. Fan Motors: Motors, 1/2 hp and Smaller: Permanent-split capacitor, multispeed motor with integral thermal-overload protection.
- G. Motors, 3/4 hp and Larger: Totally enclosed with permanently lubricated ball bearings.
- H. Accessories: Provide the followings accessories:
 - 1. Horizontal Configuration: Louver fin diffuser.
- I. Controls: Unit controls to be provided by others.

- J. Source Quality Control: Test propeller unit heater coils according to ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before unit heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install unit heaters level and plumb.
- B. Install unit heaters to comply with NFPA 90A.
- C. Suspend propeller unit heaters from structure with rubber-in-shear vibration isolators (rubber hangers). Vibration isolators are specified in Division 15 Section "Mechanical Vibration Controls and Seismic Restraints."
- D. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Unless otherwise indicated, install shutoff valve and union or flange at each connection.
- C. Install piping adjacent to machine to allow service and maintenance.
- D. Ground equipment.
- E. 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 and UL 486B.

3.4 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing and report results in writing:
 - 1. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Test and adjust controls and safeties.
- B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.5 CLEANING

- A. After installing units, clean cabinet unit heaters internally according to manufacturer's written instructions.
- B. Install new filters in each cabinet unit heater within two weeks after Substantial Completion.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain unit heaters.
 - 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
 - 2. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
 - 3. Schedule training with Owner, through Engineer, with at least seven days' advance notice.

END OF SECTION 23 8239

SECTION 26 0500

COMMON WORK RESULTS FOR ELECTRICAL

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. Electrical equipment coordination and installation.
 - 2. Sleeves for raceways and cables.
 - 3. Sleeve seals.
 - 4. Grout.
 - 5. Common electrical installation requirements.
- B. General Requirements
 - 1. Provide all labor and materials necessary for the complete installation of electrical systems shown on the Contract Documents and specified in this Division.
 - 2. Include minor items which are obviously and reasonably necessary to complete the work even though not specifically mentioned in the Contract Documents. Such items include bolts, nuts, anchors, brackets, sleeves, and minor offsets in conduit etc.
 - 3. Some equipment and materials provided under Divisions 21, 22 23, 26 and 28 may require composite work crews because of trade jurisdiction. Where this occurs, include in the bid this portion of the composite crew labor costs. It is the Contractor's responsibility to review Divisions 21, 22 23, 26, and 28 Contract Documents to determine where these composite crews are required.
 - 4. Where material quantities are shown, they are for the convenience of the Contractor only. The Contractor shall be responsible to verify all quantities.

1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.
- C. ASTM: American Society for Testing and Materials.
- D. NECA: National Electrical Contractors Association.
- E. Provide: Furnish and install, complete for intended use.

- F. Furnish: Supply and deliver to project site, ready for unloading, unpacking, assembly, installation and similar operations.
- G. Install: Unload, unpack, assemble, erect, place, anchor, apply, finish, wire, complete for intended use.
- H. Connect: To bring service to the equipment and make final attachment including necessary switches, outlets, boxes, terminations, etc.
- I. Conduit: Includes in addition to conduit, all fittings, pull boxes, hangers and other supports and accessories related to such conduit.
- J. Concealed: Hidden from sight in chases, furred spaces, shafts, hung ceilings, embedded in construction, in crawl spaces or buried.
- K. Exposed: Not installed underground nor concealed as defined above.
- L. Building structure or building structural members: Consists of steel columns, steel beams, steel joists (top chord and at panel points), concrete walls and concrete block walls, Metal decking, joist bridging and bottom chords of bar joists shall not be construed as building structure nor as a building structural member for the purpose of support.

1.4 SUBMITTALS

- A. Product Data: For sleeve seals.

1.5 REFERENCES

- A. A partial list of governing codes follows and shall be considered as minimum requirements:
 - 1. National Electrical Code (NEC)
 - 2. City, State and Local Electrical Installation Codes
 - 3. International Building Code (IBC)
 - 4. City, State and Local Building Codes and Ordinances
 - 5. City, State and Local Fire Codes and Regulations
 - 6. Occupational Safety and Health Administration Regulations (OSHA)
 - 7. Americans with Disabilities Act (ADA)
 - 8. State Board of Health Codes and Regulations
- B. The following is a list of organizations and their abbreviations where referred to in the specifications as standards of construction.
 - 1. ANSI - American National Standards Institute
 - 2. ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers
 - 3. CBM – Certified Ballast Manufacturer
 - 4. ETL – Electrical Testing Laboratory
 - 5. IEEE - Institute of Electrical and Electronic Engineers

6. IES - Illuminating Engineering Society
 7. NBFU - National Board of Fire Underwriters
 8. NECA – National Electrical Contractor’s Association
 9. NEC - National Electrical Code
 10. NEMA - National Electrical Manufacturers Association
 11. NESC – National Electric Safety Code
 12. NFPA - National Fire Protection Association
 13. OSHA - Occupational Safety and Health Administration
 14. UL - Underwriters' Laboratories, Inc.
- C. Higher quality of workmanship and materials indicated in the Contract documents takes precedence over that allowed in referenced codes and standards.
- D. Obtain and pay for all permits, licenses, and other fees necessary in order to complete the work of the project.
- E. Fees assessed by the electrical utility company for the permanent electric service installation or modifications shall be paid directly to the utility company by the Owner.

1.6 STATE AND LOCAL SALES TAXES

- A. Pay all applicable State and Local taxes imposed for electrical construction work.

1.7 DRAWING INTERPRETATION AND COORDINATION

- A. The extent of the system of equipment, materials, panels, cabinets, conduits, wire, luminaries, etc., as shown on the drawings are diagrammatic indicating the general arrangement, unless noted otherwise by dimensions or a detailed drawing.
1. The plans are intended to show direction, capacity, size, approximate location and general relationship of one work phase to another. The drawings are not intended to be scaled for rough-in measurements nor to serve as shop drawings.
 2. The contractor shall consult the architectural, structural, mechanical, or equipment drawings for dimensions, obstructions, and location of equipment for other trades. Any discrepancies between architectural, structural, mechanical or equipment drawings and the electrical work shown on the drawings shall be reported to the owner/engineer for adjustment.
 3. Outlet devices, switches, panels, cabinets, fixtures and special equipment are shown on the drawings only in a schematic manner and not necessarily in their specific location. The contractor shall be responsible for exact locations of these devices to form a functional and aesthetic installation either by careful review of all architectural elevations, tile patterns, surface finishes, and equipment arrangements or by consultation with the owner/engineer and other trades involved.
- B. Review the pertinent shop drawing submittals of all other trades. Report any conflicts to the Architect/Engineer. When equipment is substituted during the shop drawing submittal process, costs associated with changes to the original bid documents shall be paid by the contractor/trade initiating the equipment change.

1.8 SUBSTITUTION OF MATERIALS

- A. Prior to the bidding/award of the project, interested parties may request approval of substitute equipment and materials for those specified. Requests must be submitted to the Engineer in writing and received within 10 working days prior to the bid opening for consideration.
- B. Substitution submittals shall include a complete description of equipment or materials, manufacturer's name, model or catalog number, test, performance of photometric data, and listing of all standard and optional features or accessories.
- C. Acceptance of substituted materials does not relieve the Contractor of the responsibility to provide materials and equipment which conform to the minimum quality requirements set forth in these specifications.
- D. When equipment is substituted during the shop drawing submittal process without following the steps outlined above, all costs associated with changes to the original bid documents shall be paid by the contractor/trade initiating the equipment change(s).

1.9 PROJECT SUBMITTALS

- A. Shop Drawings:
 - 1. Submit shop drawings to the Engineer for review within 30 calendar days after notification of award of Contract. Shop drawings for items with critical delivery dates which could affect the progress of this project shall be submitted immediately and the Engineer shall be notified of the need for a timely review.
 - 2. Carefully examine all shop drawings noting capacity, arrangement and physical dimensions and mark the drawings as being reviewed and approved prior to submitting to the Engineer. Where catalog data is submitted which includes items which do not apply to this project, those items shall be clearly marked out or relevant items clearly noted. Any deviations from the Contract Documents shall be so noted by the Contractor or equipment supplier. The intent and requirements of the Drawings and Specifications shall be adhered to at all times and are not waived or superseded in any way by the shop drawing submittal or review.
 - 3. The Contractor shall verify that equipment proposed to be furnished will fit in the available space. Conflicts shall be brought to the Engineer's attention prior to ordering the equipment.
 - 4. Each shop drawing shall include the project name, names of the Architect, Engineer, Contractor, manufacturer, and supplier. Also include the name, address and telephone number of the contact representative. Each shop drawing shall clearly call out the Section number of where the equipment is specified. Shop drawings not including the above information will be returned without review for re-submittal.
 - 5. Submit a minimum of six (6) copies of each shop drawing. The Engineer will retain one (1) copy of all shop drawings, send one (1) copy to the Architect and return the remaining copies to the General Contractor. Contractor shall retain two (2) copies, which shall be incorporated in Operation and Maintenance Manuals as described in Part 3 of this Section. Shop drawings are to be reviewed and initialed by the Engineer before purchasing equipment or before fabrication

or erection of materials is started except under special circumstances as determined by the Engineer.

6. The Engineer will require a minimum of two weeks, excluding transmittal time, to review shop drawings. The Contractor shall allow for this when scheduling work.
7. If returned shop drawings are marked "NO EXCEPTIONS TAKEN", no additional submittal is required. If the shop drawing is marked "MAKE CORRECTIONS NOTED", the changes noted on the shop drawings are to be incorporated, with no further resubmittal required. If marked "REVISE AND RESUBMIT", changes noted on the shop drawings are to be made and the drawings resubmitted for review. If marked "REJECTED", the equipment submitted is unacceptable and different equipment or materials need to be submitted. Only one rejected shop drawing will be returned to the Contractor.

B. Record Documents

1. Maintain at the job site one (1) complete set of all contract documents, change orders, and shop drawings. Mark up the documents to show all modifications that occur during the course of construction.
2. Note locations of concealed utilities, dimensioned from prominent building lines.
3. Note size and locations of major raceways, control devices, and distribution and branch circuitry.
4. Note fuse and circuit breaker sizes, settings, and arrangements.

C. Operation And Maintenance Manuals

1. Before Certificate of Substantial Completion is issued, assemble and deliver to the Engineer two (2) sets of Operation and Maintenance Manuals which includes all equipment and materials provided under Division 16. Submit information in a 3-ring hard cover binder with all data organized according to Section numbers and indexed accordingly. Label cover of manuals with project name, date of completion, and Electrical Contractor's name, address, and telephone number.
2. Manuals shall include, but not be limited to, the following:
 - a. Copies of final approved shop drawings.
 - b. Copies of manufacturer's warranties.
 - c. Operating instructions for equipment.
 - d. Wiring and installation instructions for equipment.
 - e. Recommended maintenance schedules and procedures for equipment.
 - f. Recommended trouble shooting procedures for equipment.
 - g. Equipment parts list.
 - h. Settings/adjustments/calibrations for systems as required.
 - i. Local equipment suppliers/ reps names, addresses, and telephone numbers.
 - j. Equipment manufacturer's names, addresses, and telephones numbers.

- k. Sub-contractors names, addresses, and telephone numbers.
 - l. Refer to individual Sections in Division 16 for additional requirements.
3. Cross out or delete all information shown on shop drawings and other literature definitely not applying to this particular project and its equipment installed.

1.10 CADD DRAWING FILES

- A. The electrical CADD drawing files prepared by Sebesta Blomberg for this Project are instruments of Sebesta Blomberg's service for use solely with respect to this Project. During the course of the implementation of the Project, and with Sebesta Blomberg's approval, others shall be permitted to obtain copies of the electrical CADD drawing files for the preparation of Shop Drawings. These electrical CADD drawing files shall not be used on other projects, for additions to this Project, or for completion of this Project by Others. Any intentional or unintentional revisions, additions, or deletions to these electrical CADD drawing files shall be made at the full risk of the person(s) making such revisions, additions, or deletions, and such person(s) shall hold harmless and indemnify Sebesta Blomberg of any and all responsibilities and liabilities.
- B. The CD Rom diskettes are not to be construed as updated as-built construction documents. The diskettes reflect only bidding documentation of original Construction Drawings. Addendums or written changes occurring during the construction process may not be incorporated into the electrical CADD drawing files.

1.11 ENVIRONMENTAL REQUIREMENTS

- A. No asbestos or PCB containing materials of any type shall be used on this Project except in cases where acceptable substitutions have not been found for asbestos materials as in high temperature applications. If an asbestos containing material is used on this project because of that reason, that material shall be identified in shop drawings with a letter stating the reason for its use and the acceptability of that material and its use to all applicable Federal, State and Local regulations. No asbestos containing materials will be allowed on this project without such letter being submitted to and reviewed by the Engineer.

1.12 TEMPORARY LIGHT AND POWER

- A. General
1. Provide temporary light and power for use of all trades.
 2. Energy costs paid by the Owner.
 3. Install or remove system as soon as project dictates.
- B. Products
1. Materials used need not be new but should be electrically and mechanically safe.
 2. Materials shall remain the property of the Contractor.
 3. All products shall adhere to Division 16 of these specifications.
 4. Lighting units to have basket protective lamp.
 5. Circuits for receptacles shall have ground fault circuit interrupter.
 6. Temporary equipment exposed to weather must be suited for its purpose.

1.13 COORDINATION

- A. Coordinate arrangement, mounting, and support of electrical equipment:
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 - 3. To allow right of way for piping and conduit installed at required slope.
 - 4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel.
 - 1. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
 - b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE SEALS

- 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. Calpico, Inc.
 - c. Metraflex Co.

- d. Pipeline Seal and Insulator, Inc.
2. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
3. Pressure Plates: Plastic. Include two for each sealing element.
4. 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.

2.3 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- E. Cut sleeves to length for mounting flush with both surfaces of walls.
- F. Extend sleeves installed in floors 2 inches above finished floor level.

- G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- H. Seal space outside of sleeves with grout for penetrations of concrete and masonry
 - 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
- I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
- J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."
- K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

- A. Install to seal exterior wall penetrations.
- B. Use 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.

3.4 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.5 ENVIRONMENTAL REQUIREMENTS

- A. Remove no asbestos containing materials of any kind. If asbestos containing materials are suspected, immediately stop work and notify the Owner.
- B. Take caution not to disturb asbestos materials. If this does not appear to be possible, stop work and notify the Owner.
- C. Do not dispose of any PCB containing materials of any kind. If PCB containing materials are found, place these items in containers provided by the Owner. Owner will dispose of all PCB containing material.

3.6 TEMPORARY LIGHT AND POWER

- A. Execution
 - 1. Size to suit temporary loads of the project.
 - 2. Provide distribution to loads such as panels, temporary heating etc.
 - 3. Extend lighting and power to all areas of the project as required.
 - 4. Maintain temporary lighting and power system.
 - 5. Provide and maintain all lamps.

3.7 REGULATORY REQUIREMENTS

- A. Initiate, maintain and supervise all safety precautions required in connection with his Work, including regulations of the Occupational Safety and Health Administration (OSHA) and other governing agencies.

3.8 WORKMANSHIP

- A. Conduit, busduct, cable tray, equipment, etc. may be shown with excess clearances for clarity. Group conduit and arrange conduit, busduct, cable tray and equipment to present a neat appearance and to avoid blocking passageways.
- B. It is the intent of these Drawings and Specifications that most conduits will be concealed. Where conduits are exposed, run as close to ceilings and/or walls as possible and install parallel with adjacent structural or architectural elements.
- C. Sequence, coordinate and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building. Install materials and equipment giving right-of-way priority to systems required to be installed at a specified elevation or specified slope.
- D. Install material and equipment in accordance with manufacturers' recommendations, instructions, and current NECA standards.
- E. Do not scale drawings but rather take measurements at the building site to properly locate work.
- F. Very exact locations of outlets to form a functional and aesthetic installation by careful review of all architectural elevations, tile patterns, surface finishes, millwork construction, and equipment arrangements.
- G. Install equipment and materials to provide required access for servicing and maintenance. Coordinate final equipment location with required access panels and doors. Allow ample space for removal of all parts that require replacement or servicing.

3.9 GUARANTEES

- A. Guarantee all work and materials for the minimum period of one (1) year, except where a longer period of time is specified elsewhere, after completion of the Work as evidenced by issuance of Certificate of Substantial Completion. Warranty period for items appearing on the final punch begins at approval of the final pay application.

- B. Perform the necessary paperwork to pass extended manufacturer's warranties on to the Owner.

3.10 ENERGY CONSERVATION REBATES

- A. Perform all required actions to obtain all utility company energy conservation rebates to which the Owner is entitled. Obtain, complete, and submit the required forms and follow up to assure that the Owner has received the appropriate rebate forms.

3.11 PROTECTION

- A. Cover openings and equipment, where set, to prevent obstruction to conduits, breakage, misuse or disfigurement of equipment. Cover openings in equipment immediately upon uncrating or receipt at the job site and retain covers until permanent connection is made.
- B. When a portion of the building is to be occupied by the Owner prior to Substantial Completion of the entire Project, arrangements will be made to transfer responsibility for protection and housekeeping tasks from the Contractor to the Owner.

3.12 CLEANING

- A. Daily cleaning: As specified in Division 1 - Construction Cleaning.
- B. All new and existing electrical equipment enclosures that are affected in the project shall be cleaned using a vacuum to remove all construction debris.

3.13 SYSTEM START-UP AND INSTRUCTIONS

- A. Prior to start-up, lubricate, charge, fill, etc., all equipment, per manufacturer's recommendations.
- B. Test and inspect all work required to be concealed within construction spaces before permanently covering.
- C. Prior to Final Inspection of electrical systems, each system shall be run through all operating modes to verify proper operation. After the Contractor has verified that all systems are operating properly, he shall notify the Engineer in writing that all systems are functioning properly, including the date and method of testing.
- D. All instruments, load banks, and equipment required during testing, shall be furnished by the Contractor.
- E. All electricity, natural gas, and other fuel necessary for use in testing and adjusting and for the operation period will be supplied by the Owner.
- F. After proper operation has been verified for each system, instruct the Owner's designated personnel in the operation of each electrical system immediately prior to acceptance by Owner. Present to the Owner for his signature a form that includes the system operated, date of instruction, and Owner and Contractor's personnel present. Give a copy of signed form to Owner and send a copy to the Architect and Engineer. Give full instructions in the care, adjustment and operation of all parts of the electrical system and equipment to the Owner's employees who are to have charge of the equipment.

3.14 FINAL OBSERVATION

- A. A final observation of the electrical systems is required before final payment. When the Contractor feels that all systems are fully completed and operational, he shall request that a final observation be performed by the Engineer. The Engineer will then schedule an observation and generate a list of items which need to be corrected or completed before Contract Closeout. If the Engineer is requested to make a final observation by the Contractor, and the Engineer finds the work is not complete enough to perform that observation, the Contractor will compensate the Engineer for his time. The Contractor will then perform the necessary work to complete the project and again request a Final Observation.

3.15 INSTRUCTION OF OWNERS EMPLOYEES

- A. Provide without expense to the Owner the services of competent instructors, who will give full instructions in the care, adjustment and operation of all parts of the electrical system and equipment to the Owner's employees who are to have charge of the equipment.
- B. Each instructor shall be thoroughly familiar with all parts of the installation on which he is to give instructions and shall have full knowledge of the operating theory and practical operation-maintenance work. Factory trained instructors shall be employed whenever they are available.
- C. Instructions shall be given during the regular work week after the building has been accepted and turned over to the Owner for regular operation. Provide a minimum of one man-week (40 hours) of instructions.
- D. Document all instructions and include with Operation and Maintenance Manuals.

3.16 COMMISSIONING

- A. Where applicable, coordinate special testing requirements and commissioning plan schedule with other trades.

END OF SECTION 260500

SECTION 26 0519

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

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. Refer to 26 0500 for General Electrical Requirements.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.
 - 3. Sleeves and sleeve seals for cables.

1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.
- C. Cable: Multi-conductor, insulated, with outer sheath.
- D. CPE: Chlorinated Polyethylene.
- E. CSPE: Chlorosulfonated Polyethylene.
- F. EPR: Ethylene Propylene Rubber.
- G. FR: Flame Retardant.
- H. PVC: Polyvinyl chloride.
- I. TP: Twisted pair without shield.
- J. TSP: Twisted shielded pair.
- K. TST: Twisted shielded triad.
- L. Wire: Single conductor, insulated, with or without outer jacket depending upon type.
- M. XLP: Cross-linked Polyethylene.

1.4 SUBMITTALS

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

- B. Qualification Data: For testing agency.
- C. Field quality-control test reports.

1.5 QUALITY ASSURANCE

- A. 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.
- B. Comply with NFPA 70 and test in accordance with UL 44 and 854 standards.

1.6 COORDINATION

- A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- B. Determine required separation between cable and other work.
- C. Determine cable routing to avoid interference with other work.

1.7 PROJECT CONDITIONS

- A. Verify that field measurements are as shown on Drawings.
- B. Conductor sizes are based on copper unless indicated as aluminum or "AL".
- C. Wire and cable routing shown on Drawings is approximate unless dimensioned. Route wire and cable as required to meet Project Conditions.
- D. Where wire and cable routing is not shown, and destination only is indicated, determine exact routing and lengths required.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- 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. American Insulated Wire Corp.; a Leviton Company.
 - 2. General Cable Corporation.
 - 3. Senator Wire & Cable Company.
 - 4. Southwire Company.
- C. Building Wire and Cable:
 - 1. Type THHN/THWN:
 - a. Conductor: Copper

- b. Stranded single conductor, 7 or 19 strand.
 - c. 600 volt rated PVC insulation.
 - d. Nylon jacket.
 - e. 75°C wet and dry locations.
 - f. Standards: UL 83.
2. Type XHHW-2:
- a. Conductor: Copper
 - b. Stranded single conductor, 7 or 19 strand.
 - c. 600 volt rated XLP insulation.
 - d. 90°C dry and wet locations.
 - e. Standards:
 - (1) ICEA S-95-658/NEMA WC70.
 - (2) UL 44.

2.2 CONNECTORS AND SPLICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- 1. AFC Cable Systems, Inc.
 - 2. Hubbell Power Systems, Inc.
 - 3. O-Z/Gedney; EGS Electrical Group LLC.
 - 4. 3M; Electrical Products Division.
 - 5. Tyco Electronics Corp.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SLEEVES FOR CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.4 SLEEVE SEALS

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

- B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
 - 1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - 2. Pressure Plates: Plastic. 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.

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.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Feeders: Type THHN-THWN, single conductors in raceway.
- B. Branch Circuits: Type THHN-THWN, single conductors in raceway.
- C. Class 1 or 2 Control Circuits: Type THHN-THWN, in raceway.
- D. Unless specifically noted in the above paragraphs, multiconductor cable is prohibited, except if allowed for specific applications by other specification sections.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- B. 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.
- C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.
- D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- E. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."
- F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

- G. Install wiring in accordance with NECA "Standard of Installation" and manufacturer's instructions.

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 and UL 486B.
- B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
 - 1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Rectangular Sleeve Minimum Metal Thickness:
 - 1. For sleeve rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
 - 2. For sleeve rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.
- E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- F. Cut sleeves to length for mounting flush with both wall surfaces.
- G. Extend sleeves installed in floors 2 inches above finished floor level.
- H. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
- I. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.
- J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."
- K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Penetration Firestopping."

- L. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.
- M. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- N. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.6 SLEEVE-SEAL INSTALLATION

- A. Install to seal underground exterior-wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

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 Division 07 Section "Penetration Firestopping."
- B. Wrap conductors of same circuit entering from separate conduit together as a single cable.
- C. Follow tape manufacturers installation instructions.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- C. Test Reports: Prepare a written report to record the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- D. Remove and replace malfunctioning units and retest as specified above.

SECTION 26 0526

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Refer to 26 0500 for General Electrical Requirements.

1.2 SUMMARY

- A. Section Includes: Grounding systems and equipment.

1.3 REFERENCES

- A. Latest Edition of Reference Standards.
 - 1. American Society for Testing and Materials (ASTM):
 - a. B8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
 - 2. National Fire Protection Association (NFPA):
 - a. 70 – National Electrical Code (NEC).
 - 3. Underwriters Laboratories, Inc. (UL):
 - a. 467 – Grounding and Bonding Equipment

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Manufacturer's Instructions: Include instructions for storage, handling, protection, examination, preparation and installation of exothermic connectors.

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. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 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 B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
 - 4. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 5. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, sizes as indicated on drawings (minimum 1/4" thickness unless otherwise noted), with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

2.2 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. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.
 - 1. Pipe Connectors: Clamp type, sized for pipe.
 - 2. UL 467 listed.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
 - 1. Molecular Weld
 - a. Current capacity to match capacity of conductor.

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. Isolated Grounding Conductors: Green-colored insulation with 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.
- C. Grounding Bus: Install where indicated on drawings.
 - 1. Install bus on insulated spacers 2 inches minimum from wall, 6 inches 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 to specified height above floor; connect to horizontal bus.

D. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
1. Conductor is in addition to power conductors listed in cable tabulation.
 2. Size grounding conductors not sized on Drawings per NEC 250-122.
 3. Do not splice equipment grounding conductors.
- B. 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.
- C. 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.
- D. 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.
- E. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.
1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
 2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-12-inch grounding bus.
 3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
- F. Bond 480:120/208 VAC transformer secondary neutrals to the supplying distribution equipment ground bus and to the building grounding system.

- G. Control devices (switches, indicating lights, meters, starters, relays, etc.) mounted in MCC's switchgear, control panels, or other metal enclosures are considered grounded if the enclosure ground lug or ground bus is properly grounded.
- H. Bond lightning protection equipment to the building grounding system.

3.3 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.
 - 1. Remove paint, rust, or other non-conducting material from contact surfaces before making ground connections.
 - 2. Provide schedule 40 PVC protective sleeves where ground conductor pass through floor slabs or above-grade building walls.
- B. 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.
- C. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.
- D. Raceway Grounding – Conduit:
 - 1. Metallic conduit to be electrically continuous
 - a. Make all metallic raceway fittings and ground clamps tight to ensure equipment grounding system will operate continuously at ground potential to provide low impedance current path for proper operation of overcurrent devices during possible ground fault conditions.
 - 2. Provide grounding type insulation bushings:
 - a. For equipment not supplied with conduit hubs.
 - b. On ends of ductbank constructed of steel conduits.
 - 3. Bond all conduit to:
 - a. Equipment ground bus or grounding lug.
 - 4. Use double locknuts at all panels.
 - 5. Use grounding bushings on conduits 2 Inches or larger.
 - 6. Provide bonding jumpers in conduits installed in concentric knockouts.
 - 7. Provide bonding jumpers same size as largest ground conductor run within conduit.

- E. Raceway Grounding – Cable Tray:
 - 1. Metallic cable tray to be electrically continuous.
 - 2. Provide a bare No. 2 copper grounding conductor run within full length of cable tray system.
 - a. Install one ground lug per tray section and bond to ground conductor.
 - b. Bond tray grounding conductor to building grounding system.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports to include with Operations and Maintenance manuals.
- E. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
 - 2. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 ohm(s).
- F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 26 0529

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Refer to 26 0500 for General Electrical Requirements.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Hangers and supports for electrical equipment and systems.

DEFINITIONS & REFERENCES

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit.
- D. Latest Edition of Referenced Standards:
 - 1. National Fire Protection Association (NFPA):
 - a. 70 – National Electrical Code (NEC).
 - 2. National Electrical Contractors Association (NECA):
 - a. 1 – Standard Practices for Good Workmanship in Electrical Contracting.

1.4 PERFORMANCE REQUIREMENTS

- A. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.5 SUBMITTALS

- A. Refer to Section 26 01 00 “Submittals”
- B. Product Data: For the following:
 - 1. Steel slotted support systems.
 - 2. Nonmetallic slotted support systems.
 - 3. Provide manufacturer’s catalog data for fastening systems.
- C. Welding certificates.

1.6 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.

1.7 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 installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 PRODUCT REQUIREMENTS

- A. Materials and finishes:
 - 1. Provide adequate corrosion resistance.
- B. Provide materials, sizes, and types of anchors, fasteners and supports to carry the loads. Consider weight of wire when selecting products.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.
 - f. Unistrut; Tyco International, Ltd.
 - g. Wesanco, Inc.
 - 2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - 4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 5. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

- C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored 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 malleable iron.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - (1) Hilti Inc.
 - (2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - (3) MKT Fastening, LLC.
 - (4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
 - 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 in which used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - (1) Cooper B-Line, Inc.; a division of Cooper Industries.
 - (2) Empire Tool and Manufacturing Co., Inc.
 - (3) Hilti Inc.
 - (4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - (5) MKT Fastening, LLC.
 - 3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
 - 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
 - 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
 - 6. Toggle Bolts: All-steel springhead type.
 - 7. Hanger Rods: Galvanized threaded steel with ¼ inch minimum diameter.
- G. Vibration Mounts: Refer to Section 260548.

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 Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where its Table 1 lists maximum spacings less than stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with 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.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, raceways, cables, and conduits may not be supported by openings through structure members, although permitted in NFPA 70.
- C. In exposed areas in the Hangar, install supports and associated devices as high as possible against roof deck. Do not install on structure such as across joists or beams.
- D. 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.
- E. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.

3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 4. To Existing Concrete: Expansion anchor fasteners.
 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
 6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
 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.
- F. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 05 Section "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 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.
- B. Touchup: Comply with requirements in Division 09 painting Sections 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 A 780.

END OF SECTION 260529

SECTION 26 0533

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Refer to 26 0500 for General Electrical Requirements.

1.2 SUMMARY

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. ENT: Electrical nonmetallic tubing.
- C. EPDM: Ethylene-propylene-diene terpolymer rubber.
- D. FMC: Flexible metal conduit.
- E. IMC: Intermediate metal conduit.
- F. LFMC: Liquidtight flexible metal conduit.
- G. LFNC: Liquidtight flexible nonmetallic conduit.
- H. NBR: Acrylonitrile-butadiene rubber.
- I. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

- A. Refer to Section 26 01 00 "Submittals"
- B. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- C. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Custom enclosures and cabinets.
- D. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1. Structural members in the paths of conduit groups with common supports.

2. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.

1.5 QUALITY ASSURANCE

- A. 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.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. AFC Cable Systems, Inc.
 2. Alflex Inc.
 3. Allied Tube & Conduit; a Tyco International Ltd. Co.
 4. Anamet Electrical, Inc.; Anaconda Metal Hose.
 5. Carlon
 6. Electri-Flex Co.
 7. FRE (Fiber Reinforced Engineered Products)
 8. LCP (Non-Metallic)
 9. Manhattan/CDT/Cole-Flex.
 10. Maverick Tube Corporation.
 11. Omega
 12. O-Z Gedney; a unit of General Signal.
 13. Republic
 14. Triangle
 15. V.A.W. of America
 16. Wheatland Tube Company.
 17. Youngstown
- B. Rigid Steel Conduit: ANSI C80.1.
- C. Aluminum Rigid Conduit: ANSI C80.5.
- D. IMC: ANSI C80.6.
- E. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
 1. Comply with NEMA RN 1.
 2. Coating Thickness: 0.040 inch, minimum.

- F. EMT: ANSI C80.3.
- G. FMC: Zinc-coated steel.
- H. LFMC: Flexible steel conduit with PVC jacket.
- I. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
 - 2. Fittings for EMT: Steel, set-screw type.
 - 3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch, with overlapping sleeves protecting threaded joints.
- J. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.
- K. All metal conduit to be hot dip galvanized process or aluminum.

2.2 NONMETALLIC CONDUIT AND TUBING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Anamet Electrical, Inc.; Anaconda Metal Hose.
 - 3. Arnco Corporation.
 - 4. CANTEX Inc.
 - 5. CertainTeed Corp.; Pipe & Plastics Group.
 - 6. Condux International, Inc.
 - 7. ElecSYS, Inc.
 - 8. Electri-Flex Co.
 - 9. Lamson & Sessions; Carlon Electrical Products.
 - 10. Manhattan/CDT/Cole-Flex.
 - 11. RACO; a Hubbell Company.
 - 12. Thomas & Betts Corporation.
- B. ENT: NEMA TC 13.
- C. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.
- D. LFNC: UL 1660.
- E. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.
- F. Fittings for LFNC: UL 514B.

2.3 METAL WIREWAYS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper B-Line, Inc.
 - 2. Hoffman.
 - 3. Square D; Schneider Electric.
- B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated or required for installation location.
- C. Fittings and Accessories: Include 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.

2.4 NONMETALLIC WIREWAYS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Hoffman.
 - 2. Lamson & Sessions; Carlon Electrical Products.
- B. Description: Fiberglass polyester, extruded and fabricated to size and shape indicated, with no holes or knockouts. Cover is gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections are flanged, with stainless-steel screws and oil-resistant gaskets.
- C. Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.
- D. Fittings and Accessories: Include 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.

2.5 SURFACE RACEWAYS

- A. Surface Metal Raceways: Galvanized steel with snap-on covers. 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. Thomas & Betts Corporation.
 - b. Walker Systems, Inc.; Wiremold Company (The).
 - c. Wiremold Company (The); Electrical Sales Division.
 - 2. Refer to drawings for services to be provided in surface metal raceways.

2.6 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
 2. EGS/Appleton Electric.
 3. Erickson Electrical Equipment Company.
 4. Hoffman.
 5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
 6. O-Z/Gedney; a unit of General Signal.
 7. RACO; a Hubbell Company.
 8. Robroy Industries, Inc.; Enclosure Division.
 9. Scott Fetzer Co.; Adalet Division.
 10. Spring City Electrical Manufacturing Company.
 11. Thomas & Betts Corporation.
 12. Walker Systems, Inc.; Wiremold Company (The).
 13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.
- B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- D. Nonmetallic Outlet and Device Boxes: NEMA OS 2.
- E. Metal Floor Boxes: Cast metal fully adjustable, rectangular.
- F. Nonmetallic Floor Boxes: Nonadjustable, round.
- G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- H. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.
- I. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 2. Nonmetallic Enclosures: Plastic
- J. Fiberglass cable-pulling enclosure
- a. Rectangular fiberglass composite.
 - b. Suitable for direct burial with pedestrian traffic.
 - c. -50 Degrees F, chemical, sunlight, and weather resistant.
 - d. Matching top with imprinted "Electric" logo.

- e. Access points to facilitate pulling of electrical cables in buried conduit runs.

K. Cabinets:

1. NEMA 250, Type 1, 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.

2.7 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Description: Comply with SCTE 77.

1. Color of Frame and Cover: Gray.
2. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, as indicated for each service.
6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
7. Handholes 12 inches wide by 24 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

B. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete.

2.8 SLEEVES FOR RACEWAYS

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

2.9 SLEEVE SEALS

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

- B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
 - 1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - 2. Pressure Plates: Plastic. 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.

2.10 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

- A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes 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 a independent testing agency.
 - 2. Strength tests of complete boxes and covers shall be by either 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 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
 - 1. Exposed Conduit: Rigid steel conduit.
 - 2. Concealed Conduit, Aboveground: Rigid steel conduit.
 - 3. Underground Conduit: RNC, Type EPC-40-PVC, direct buried.
 - 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 - 5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
 - 6. Application of Handholes and Boxes for Underground Wiring:
 - a. Handholes and Pull Boxes in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Fiberglass enclosures with polymer-concrete frame and cover SCTE 77, Tier 15 structural load rating.
 - b. Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Heavy-duty fiberglass units with polymer-concrete frame and cover, SCTE 77, Tier 8 structural load rating.

- c. Handholes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf vertical loading.
- B. Indoors: Apply raceway products as specified below,
 1. Exposed, Not Subject to Physical Damage: EMT.
 2. Exposed, Not Subject to Severe Physical Damage: EMT.
 3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:
 - a. Feeders raceway from through-floor penetration to panelboards.
 4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 6. Damp or Wet Locations: Rigid steel conduit.
 7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.
- C. Minimum Raceway Size: 3/4-inch trade size. For homeruns and 3/4 Inch trade size for branch circuits.
- 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.
 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.
- E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

3.2 INSTALLATION

- A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
- B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.
- D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."
- E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

- F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
- H. Raceways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
 - 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 - 3. Change from ENT to RNC, rigid steel conduit, or IMC, as indicated in “Applications” in this Section, before rising above the floor.
- I. 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.
- J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
- K. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.
- L. Install raceway sealing fittings at suitable, approved, and accessible locations 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 at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where otherwise required by NFPA 70.
- M. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for recessed and semirecessed lighting fixtures (does not include suspended fixtures or fixtures in exposed areas), 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.
- N. 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.
- O. Set metal floor boxes level and flush with finished floor surface.
- P. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
- Q. Conceal all raceways and recess all device boxes, unless otherwise noted.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

- A. Direct-Buried Conduit:
1. Excavate trench bottom to provide firm and uniform support for conduit.
 2. Install backfill as required.
 3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction.
 4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
 5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
 - b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
 6. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits, placing them 24 inches o.c. Align planks along the width and along the centerline of conduit.

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
- D. Install handholes and boxes with bottom below the 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 the enclosure.

- F. Field-cut openings for conduits 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.

3.5 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Rectangular Sleeve Minimum Metal Thickness:
 - 1. For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
 - 2. For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.
- E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- F. Cut sleeves to length for mounting flush with both surfaces of walls.
- G. Extend sleeves installed in floors 2 inches above finished floor level.
- H. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway unless sleeve seal is to be installed.
- I. Seal space outside of sleeves with grout for penetrations of concrete and masonry.
- J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
- K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Division 07 Section "Penetration Firestopping."
- L. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
- M. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- N. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between raceway and sleeve for installing mechanical sleeve seals.

3.6 SLEEVE-SEAL INSTALLATION

- A. Install to seal underground, exterior wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.7 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.8 PROTECTION

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

SECTION 26 0536

CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Refer to 26 0500 for General Electrical Requirements.

1.2 SUMMARY

- A. This Section includes steel cable trays and accessories.

1.3 REFERENCES

- A. Latest Edition of Reference Standards:
 - 1. American Society for Testing and Materials (ASTM):
 - a. A 123 – Standard Specification for Zinc (Hot-Galvanized) Coatings on Iron and Steel Products.
 - b. A 653 – Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanized) by the Hot-Dip Process.
 - 2. National Electrical Manufacturers Association (NEMA):
 - a. VE 1 – Metallic Cable Tray Systems.
 - b. VE2 – Metal Cable Tray Installation Guidelines.
 - 3. National Fire Protection Association (NFPA):
 - a. 70 – National Electrical Code (NEC).

1.4 SUBMITTALS

- A. Product Data: Include data indicating dimensions and finishes for each type of cable tray indicated.
- B. Shop Drawings: For each type of cable tray.
 - 1. Show fabrication and installation details of cable tray, including plans, 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.
 - a. Include list of cable numbers, or other identification of cable runs, to be installed in each cable tray.
 - 2. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
 - a. Design Calculations: Calculate requirements for selecting seismic restraints.

- b. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.
- c. Retain first paragraph and subparagraphs below if Drawings do not include detailed floor plans or if Project involves unusual coordination requirements.
- 3. Calculation of required load/span rating of cable tray.
- C. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements. Show the following:
 - 1. Vertical and horizontal offsets and transitions.
 - 2. Clearances for access above and to side of cable trays.
 - 3. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
- D. Field quality-control reports.
- E. Operation and Maintenance Data: For cable trays to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain cable tray components through one source from a single manufacturer.
- 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. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Steel, factory-primed cable tray shall be stored in a well-ventilated, dry location. Unpack and dry wet materials before storage.

1.7 PROJECT CONDITIONS

- A. Verify that field measurements are as shown on Drawings.
- B. Verify routing prior to rough-in.
- C. Cable tray routing is shown on Drawings in approximate locations unless dimensioned. Route as required to complete wiring system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Chalfant Manufacturing Company.
 - 2. Cooper B-Line, Inc.
 - 3. Cope, T. J., Inc.; a subsidiary of Allied Tube & Conduit.
 - 4. GS Metals Corp.; GLOBETRAYS Products.
 - 5. MONO-SYSTEMS, Inc.

6. MPHusky.
7. PW Industries.

2.2 MATERIALS AND FINISHES

- A. Basket-type cable tray
 1. Material:
 - a. Steel:
 - (1) Finish: PVC coated
 2. Dimensions:
 - a. Inside Width: As indicated
 - b. Inside Loading Depth: 3 inches.
 3. Provide manufacturer's standard clamps, hangers, brackets, splice plates, reducer plates, blind ends, barrier strips, connectors, and grounding straps.
 4. Center-hanger supports may be used only when specifically indicated.

2.3 CABLE TRAY ACCESSORIES

- A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
- B. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.4 WARNING SIGNS

- A. Lettering: 1-1/2-inch- high, black letters on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."
- B. Materials and fastening are specified in Division 26 Section "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

- A. Perform design and production tests according to NEMA VE 1.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

- A. Comply with recommendations in NEMA VE 2. Install as a complete system, including all necessary fasteners, hold-down clips, splice-plate support systems, barrier strips, hinged horizontal and vertical splice plates, elbows, reducers, tees, and crosses.
- B. Remove burrs and sharp edges from cable trays.
- C. Fasten cable tray supports to building structure.
 1. Place supports so that spans do not exceed maximum spans on schedules.
 2. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
 3. Support bus assembly to prevent twisting from eccentric loading.

4. Manufacture center-hung support, designed for 60 percent versus 40 percent eccentric loading condition, with a safety factor of 3.
5. Locate and install supports according to NEMA VE 1.
- D. Make connections to equipment with flanged fittings fastened to cable tray and to equipment. Support cable tray independent of fittings. Do not carry weight of cable tray on equipment enclosure.
- E. Install expansion connectors where cable tray crosses building expansion joint and in cable tray runs that exceed dimensions recommended in NEMA VE 1. Space connectors and set gaps according to applicable standard.
- F. Make changes in direction and elevation using standard fittings.
- G. Make cable tray connections using standard fittings.
- H. Seal penetrations through fire and smoke barriers according to Division 07 Section "Penetration Firestopping."
- I. Metallic cable tray to be electrically continuous:
 1. Provide continuity between tray components.
 - a. Bolt connectors to each section or fitting.
 - b. Tighten bolted connections per manufacturer's recommendations.
 - c. Span expansion connectors with bonding jumper.
 2. Terminate conduits connected to cable tray by a side rail bracket and clamp assembly with an insulated ground bushing and bond to cable tray.
 3. Use anti-oxidant compound to prepare aluminum contact surfaces before assembly.
 4. Connections to tray may be made using mechanical or exothermic connectors.
- J. Sleeves for Future Cables: Install capped sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
- K. Use flanged fittings to terminate cable tray systems at switchgear, motor control centers, and other equipment unless noted or shown otherwise.
- L. Workspace: Install cable trays with enough space to permit access for installing cables.
- M. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.
- N. After installation of cable trays is completed, install warning signs in visible locations on or near cable trays.

3.2 CABLE INSTALLATION

- A. Install cables only when cable tray installation has been completed and inspected.
- B. Fasten cables on horizontal runs with cable clamps or cable ties as recommended by NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.
- C. On vertical runs, fasten cables to tray every 18 inches. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.
- D. In existing construction, remove inactive or dead cables from cable tray.

- E. Install covers after installation of cable is completed.

3.3 CONNECTIONS

- A. Ground cable trays according to manufacturer's written instructions.
- B. Install an insulated equipment grounding conductor with cable tray, in addition to those required by NFPA 70.

3.4 FIELD QUALITY CONTROL

- A. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements. Perform the following field quality-control survey:
 - 1. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable tray, vibration, and thermal expansion and contraction conditions, which may cause or have caused damage.
 - 2. Verify that the number, size, and voltage of cables in cable tray do not exceed that permitted by NFPA 70. Verify that communication or data-processing circuits are separated from power circuits by barriers.
 - 3. Verify that there is no intrusion of such items as pipe, hangers, or other equipment that could damage cables.
 - 4. Remove deposits of dust, industrial process materials, trash of any description, and any blockage of tray ventilation.
 - 5. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
 - 6. Check for missing or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
 - 7. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable tray.
- B. Report results in writing.

3.5 PROTECTION

- A. Protect installed cable trays.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
 - 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by cable tray manufacturer.
 - 3. Install temporary protection for cables in open trays to protect exposed cables from falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials until the risk of damage is over.

END OF SECTION 260536

SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Refer to 26 0500 for General Electrical Requirements.

1.2 SUMMARY

- A. Section Includes:
 - 1. Identification for raceways.
 - 2. Underground-line warning tape.
 - 3. Warning labels and signs.
 - 4. Instruction signs.
 - 5. Equipment nameplates and identification labels.
 - 6. Miscellaneous identification products.

1.3 SUBMITTALS

- A. Product Data: For each electrical identification product indicated.
- B. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.
- C. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

1.4 QUALITY ASSURANCE

- A. Comply with NFPA 70.
- B. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- C. Comply with ANSI Z535.4 for safety signs and labels.
- D. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.5 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.

- D. Install identifying devices before installing acoustical ceilings and similar concealment.

1.6 REGULATORY REQUIREMENT

- A. Conform to requirements of NFPA 70
- B. Equipment, parts, components and materials are listed and labeled by UL, ETL or other independent testing agency recognized by the authority having jurisdiction.

PART 2 - PRODUCTS

2.1 RACEWAY IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
- B. Snap-Around, Color-Coding Bands for Raceways: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
 - 1. Color:
 - a. 480 Volt System: Black lettering on orange background.
 - b. 208 Volt System: Black lettering on yellow background.
 - c. Emergency Power System: White lettering on red background.
 - d. Fire Alarm System: White lettering on red background.
 - e. Other Systems: White lettering on blue background
 - 2. Legend:
 - a. 480 Volt System: "480 VOLTS"
 - b. 208 Volt System: "208 VOLTS"
 - c. Emergency Power System: "EMERGENCY SERVICE"
 - d. Fire Alarm System: "FIRE ALARM"
 - e. Other Systems: "TELEPHONE", "SECURITY", etc.

2.2 UNDERGROUND-LINE WARNING TAPE

- A. Tape:
 - 1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical utility lines.
 - 2. Printing on tape shall be permanent and shall not be damaged by burial operations.
 - 3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.
- B. Color and Printing:
 - 1. Comply with ANSI Z535.1 through ANSI Z535.5.
 - 2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE,

2.3 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.
- C. Baked-Enamel Warning Signs:
 - 1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
 - 2. 1/4-inch grommets in corners for mounting.
 - 3. Nominal size, 7 by 10 inches.
- D. Warning label and sign shall include, but are not limited to, the following legends:
 - 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 - 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.4 EQUIPMENT IDENTIFICATION NAMEPLATES AND LABELS

- A. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

2.5 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select 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 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Label all junction boxes and pull boxes with the panel and circuit number of all conductors installed.
- D. Apply identification devices to surfaces that require finish after completing finish work.
- E. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands 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.

- F. Identify contents of normally concealed junction boxes with neat lettering on the cover using a permanent black marking pen.
- G. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
 - 1. Limit use of underground-line warning tape to direct-buried cables.
 - 2. Install underground-line warning tape for both direct-buried cables and cables in raceway.
- H. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting:
 - 1. Comply with 29 CFR 1910.145.
 - 2. Identify system voltage with black letters on an orange background.
 - 3. Apply to exterior of door, cover, or other access.
 - 4. Apply to door or cover of equipment including the following:
 - a. Panelboards in unfinished spaces.
- J. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
 - 1. Labeling Instructions:
 - a. Indoor Equipment: Engraved, laminated acrylic or melamine label. 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.
 - b. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.
 - 2. Equipment to Be Labeled:
 - a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be engraved, laminated acrylic or melamine label.
 - b. Enclosures and electrical cabinets.
 - c. Access doors and panels for concealed electrical items.
 - d. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
 - e. Enclosed switches.
 - f. Enclosed circuit breakers.
 - g. Enclosed controllers.

- h. Variable-speed controllers.
- i. Contactors.

END OF SECTION 260553

SECTION 26 0923

LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Refer to 26 0500 for General Electrical Requirements.

1.2 SUMMARY

- A. This Section includes the following lighting control devices:
 - 1. Indoor photoelectric switches.
 - 2. Indoor occupancy sensors.
 - 3. Lighting contactors.
- B. Related Sections include the following:
 - 1. Division 26 Section "Wiring Devices" for wall-box dimmers and manual light switches.

1.3 DEFINITIONS

- A. LED: Light-emitting diode.
- B. PIR: Passive infrared.

1.4 SUBMITTALS

- A. Refer to Section 26 01 00 "Submittals"
- B. Product Data: For each type of product indicated.
- A. Shop Drawings: Show installation details for occupancy and light-level sensors.
 - 1. Interconnection diagrams showing field-installed wiring.
- B. Field quality-control test reports.
- C. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. 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.

1.6 COORDINATION

- A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 INDOOR PHOTOELECTRIC SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Allen-Bradley/Rockwell Automation.
 2. Eaton Electrical Inc; Cutler-Hammer Products.
 3. Intermatic, Inc.
 4. Lithonia Lighting; Acuity Lighting Group, Inc.
 5. Novitas, Inc.
 6. TORK.
 7. Touch-Plate, Inc.
 8. Watt Stopper (The).
- B. Ceiling-Mounted Photoelectric Switch: Solid-state, light-level sensor unit, with capability to detect changes in lighting levels that are perceived by the eye and adjust light levels of dimmed light fixtures. Cadmium sulfide photoresistors are not acceptable.
1. Light-Level Monitoring Range: 10 to 200 fc, with an adjustment for turn-on and turn-off levels within that range.
 2. Indicator: Two LEDs to indicate the beginning of on-off cycles.

2.2 INDOOR OCCUPANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hubbell Lighting.
 2. Leviton Mfg. Company Inc.
 3. Lithonia Lighting; Acuity Lighting Group, Inc.
 4. Novitas, Inc.
 5. TORK.
 6. Watt Stopper (The).
- B. General Description: Wall or ceiling-mounting (as indicated) solid-state units with a separate relay unit.
1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 4. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.

- c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
 6. Bypass Switch: Override the on function in case of sensor failure.
 7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; keep lighting off when selected lighting level is present.
- C. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.
1. Detector Sensitivity: 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..
 2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.
 3. Detection Coverage (Corridor): Detect occupancy within 90 feet when mounted on a 10-foot- high ceiling.
- D. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.
1. Detector Sensitivity: 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.
 2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. when mounted on a 96-inch- high ceiling.
 3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.
 4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. when mounted on a 96-inch- high ceiling.
 5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet when mounted on a 10-foot- high ceiling in a corridor not wider than 14 feet.
- E. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.
1. Sensitivity Adjustment: Separate for each sensing technology.
 2. Detector Sensitivity: 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., and 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.
 3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.

2.3 LIGHTING CONTACTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Allen-Bradley/Rockwell Automation.
 2. ASCO Power Technologies, LP; a division of Emerson Electric Co.

3. Eaton Electrical Inc.; Cutler-Hammer Products.
 4. GE Industrial Systems; Total Lighting Control.
 5. Hubbell Lighting.
 6. Lithonia Lighting; Acuity Lighting Group, Inc.
 7. Square D; Schneider Electric.
 8. TORK.
 9. Watt Stopper (The).
- B. Description: Electrically operated and mechanically held, combination type with nonfused disconnect, complying with NEMA ICS 2 and UL 508.
1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
 2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
 3. Enclosure: Comply with NEMA 250.
 4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.
- C. BAS Interface: Provide hardware interface to enable the BAS to monitor and control lighting contactors.

2.4 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cable: Cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cable: Cable with stranded-copper conductors not smaller than No. 14AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

- A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 CONTACTOR INSTALLATION

- A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 WIRING INSTALLATION

- A. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
- D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

- A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."
 - 1. Identify controlled circuits in lighting contactors.
 - 2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
 - 2. Operational Test: Verify operation of each lighting control device, and adjust time delays.
- B. Lighting control devices that fail tests and inspections are defective work.

3.6 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 260923

SECTION 26 2200

LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Refer to 260500 for General Electrical Requirements.

1.2 SUMMARY

- A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
 - 1. Distribution transformers.

1.3 DEFINITIONS & REFERENCES

- A. NETA ATS: Acceptance Testing Specification.
- B. Latest Edition of Referenced Standards:
 - 1. American National Standards Institute (ANSI):
 - a. C57.12.01 - Standard General Requirements for Dry Type Distribution and Power Transformers Including Those with Solid Cast or Encapsulated Windings.
 - b. C57.12.50 - Requirements for Ventilated Dry Type Power Transformers, 15 to 500 kVA, Three Phase With High Voltage 601 to 34,500 Volts, Low Voltage 120 to 600 Volts.
 - c. C57.12.55 - Conformance Standard for Transformers - Dry Type Transformers used in Unit Installations, Including Unit Substations.
 - 2. National Electrical Contractors Association (NECA):
 - a. "Standard of Installation".
 - 3. National Fire Protection Association (NFPA):
 - a. 70 - National Electrical Code (NEC).
 - 4. American National Standards Institute/Institute of Electrical and Electronic Engineers (ANSI/IEEE):
 - a. C57.12.91-Test Code For Dry-Type Distribution and Power Transformers.
 - 5. National Electrical Manufacturers Association (NEMA):
 - a. ST 20 - Dry Type Transformers for General Applications.
 - b. TP 1 - Guide for Determining Energy Efficiency for Distribution Transformers.
 - 6. Underwriters Laboratory, Inc (UL):
 - a. UL 1561 - Dry-Type General Purpose and Power Transformers.

1.4 SUBMITTALS

- A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.
 - 1. Three-line diagram.
 - 2. Manufacturers catalog data and specifications for all components.
- 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. Wiring Diagrams: Power, signal, and control wiring.
 - 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. Source quality-control test reports.
- D. Field quality-control test reports.
 - 1. Submit field test reports prior to initial energization.
- E. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.
- 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. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

1.6 DELIVERY, STORAGE, AND HANDLING

- A. 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.
- B. Deliver transformers individually wrapped for protection and mounted on shipping skids.
- C. Accept transformers on site. Inspect for damage.

1.7 COORDINATION

- A. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Products.
 2. General Electric Company.
 3. Square D; Schneider Electric.

2.2 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- B. Core:
1. High grade, non-aging, silicon steel with high magnetic permeability, and low hysteresis and eddy current losses.
 2. Magnetic flux densities below saturation point.
- C. Coils: Continuous windings without splices except for taps.
1. Internal Coil Connections: Brazed or pressure type.
 2. Coil Material: Copper.
 3. Impregnated with non-hygroscopic thermosetting varnish.

2.3 DISTRIBUTION TRANSFORMERS

- A. Comply with NEMA ST 20, and list and label as complying with UL 1561.
- B. Provide transformers that are constructed to withstand seismic forces specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- C. Cores: One leg per phase.
- D. Enclosure: Ventilated, NEMA 250, Type 2.
1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
- E. Transformer Enclosure Finish: Comply with NEMA 250.
1. Finish Color: Gray
- F. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.
- G. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
- H. Energy Efficiency for Transformers Rated 15 kVA and Larger:
1. Complying with NEMA TP 1, Class 1 efficiency levels.
 2. Tested according to NEMA TP 2.
- I. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.

1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
 2. Indicate value of K-factor on transformer nameplate.
- J. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
 2. Include special terminal for grounding the shield.
 3. Shield Effectiveness:
 - a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.
 - b. Common-Mode Noise Attenuation: Minimum of minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz.
 - c. Normal-Mode Noise Attenuation: Minimum of minus 52 dBA at 1.5 to 10 kHz.
- K. Wall Brackets: Manufacturer's standard brackets.
- L. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.
- M. Low-Sound-Level Requirements: Maximum sound levels, when factory tested according to IEEE C57.12.91, as follows:
1. 10 to 50 kVA: 45 dB
 2. 51 to 150 kVA: 50 dB

2.4 IDENTIFICATION DEVICES

- A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

- A. Test and inspect transformers according to IEEE C57.12.91.
- B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D. Verify that ground connections are in place and requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.
 - 1. Brace wall-mounting transformers as specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions and requirements in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

3.3 CONNECTIONS

- A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- C. Remove and replace units that do not pass tests or inspections and retest as specified above.
- D. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING

- A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
- B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.6 CLEANING

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 16461

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Refer to 260500 for General Electrical Requirements.

1.2 SUMMARY

- A. Section Includes:
 - 1. Lighting and appliance branch-circuit panelboards.
 - 2. Electronic-grade panelboards.

1.3 DEFINITIONS & REFERENCES

- A. SVR: Suppressed voltage rating.
- B. TVSS: Transient voltage surge suppressor.
- C. Latest Edition of Referenced Standards:
 - 1. National Electrical Manufacturer's Association (NEMA):
 - a. PB 1 - Panelboards.
 - b. PB 1.1 - General Instructions for Proper Installation, Operation, and Maintenance of Panelboards Rated 600 Volts or Less.
 - c. AB1 - Molded Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures.
 - d. 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
 - 2. National Electrical Contractors Association (NECA):
 - a. "Standard of Installation."
 - 3. National Fire Protection Association (NFPA):
 - a. 70 - National Electrical Code (NEC).
 - 4. Underwriters Laboratories, Inc. (UL):
 - a. 50 - Standard for Enclosures for Electrical Equipment.
 - b. 67 - Standard for Panelboards.
 - c. 489 - Molded Case Circuit Breakers, Molded Case Switches, and Circuit Breaker Enclosures.
 - d. 943 - Standard for Ground Fault Circuit Interrupters (GFCI).
 - 5. National Fire Protection Association (NFPA):

- a. 70 – National Electrical Code (NEC).
6. National Electrical Contractors Association (NECA):
 - a. "Standard of Installation."

1.4 SUBMITTALS

- A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. 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. Show tabulations of installed devices, equipment features, and ratings.
 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
 3. Detail bus configuration, current, and voltage ratings.
 4. Circuit breaker arrangement and sizes.
 5. Short-circuit current rating of panelboards and overcurrent protective devices.
 6. Include evidence of NRTL listing for series rating of installed devices.
 7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 8. Include wiring diagrams for power, signal, and control wiring.
 9. 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.
- C. 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.
- D. Panelboard Schedules: For installation in panelboards
- E. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NEMA PB 1.
- E. Comply with NFPA 70.

1.6 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.
- C. Accept products on site. Inspect for damage.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations:
 - 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 - 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding minus 22 deg F to plus 104 deg F.
 - b. Altitude: Not exceeding 6600 feet.
- B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
 - 1. Ambient temperatures within limits specified.
 - 2. Altitude not exceeding 6600 feet.
- C. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - 1. Notify Owner no fewer than fourteen days in advance of proposed interruption of electric service.

2. Do not proceed with interruption of electric service without Owner's written permission.
3. Comply with NFPA 70E.b

1.8 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.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: Five years from date of Substantial Completion.

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. Keys: Two spares for each type of panelboard cabinet lock.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Enclosures: Flush- and surface-mounted cabinets.
 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
 4. 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: Galvanized steel.
 5. Directory Card: Inside panelboard door, mounted in [transparent card holder] [metal frame with transparent protective cover].

- C. Incoming Mains Location: As required.
- D. Phase, Neutral, and Ground Buses:
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 - 3. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box.
 - 4. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
- E. Conductor Connectors: Suitable for use with conductor material and sizes.
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 2. Main and Neutral Lugs: Compression type.
 - 3. Ground Lugs and Bus-Configured Terminators: Compression type.
 - 4. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 - 5. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.
- F. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- G. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Square D; a brand of Schneider Electric.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Bus Bars:
 - 1. Fully insulated copper.
 - 2. Drilled and tapped circuit pole centers.
 - 3. Ratings as indicated on schedules.
 - 4. Solid neutral bar with solderless mechanical type connectors.
 - 5. Non-insulated copper grounding strip including:
 - a. Main ground lug.

- b. Individual grounding terminals for each circuit breaker space.
- 6. Main Lugs:
 - a. Solderless type .
 - b. Approved for copper and aluminum UL listed wire.
- D. Mains: Circuit breaker or lugs only as indicated.
- E. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- F. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.
- G. Column-Type Panelboards: Narrow gutter extension per NEC and UL requirements, with cover, to overhead junction box equipped with ground and neutral terminal buses.
 - 1. NEMA PB 1, NEMA 250 Type 1, UL 50 listed.
 - 2. Code gauge galvanized steel.
 - 3. Furnish with knockouts in side, top and bottom panels.

2.3 ELECTRONIC-GRADE PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, [provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Square D; a brand of Schneider Electric.
- B. Panelboards: NEMA PB 1; with factory-installed, integral TVSS; labeled by an NRTL for compliance with UL 67 after installing TVSS.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
- D. Main Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.
- E. Branch Overcurrent Protective Devices: Bolt-on thermal-magnetic circuit breakers.
- F. Buses:
 - 1. Copper phase and neutral buses; 200 percent capacity neutral bus and lugs.
 - 2. Copper equipment and isolated ground buses.
- G. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, wired-in solid-state, parallel-connected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, short-circuit current rating complying with UL 1449, second edition, and matching or exceeding the panelboard short-circuit rating, redundant suppression circuits, with individually fused metal-oxide varistors.
 - 1. Accessories:
 - a. Fuses rated at 200-kA interrupting capacity.
 - b. Fabrication using bolted compression lugs for internal wiring.

- c. Integral disconnect switch.
 - d. Redundant suppression circuits.
 - e. Redundant replaceable modules.
 - f. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 - g. LED indicator lights for power and protection status.
 - h. Audible alarm, with silencing switch, to indicate when protection has failed.
 - i. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 - j. Four-digit, transient-event counter set to totalize transient surges.
2. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase
 3. Minimum single-impulse current ratings, using 8-by-20-mic.sec. waveform described in IEEE C62.41.2.
 - a. Line to Neutral: 70,000A.
 - b. Line to Ground: 70,000A.
 - c. Neutral to Ground: 50,000A.
 4. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
 5. Protection modes and UL 1449 SVR for grounded wye circuits with 208Y/120-V, three-phase, four-wire circuits shall be as follows:
 - a. Line to Neutral: 400 V for 208Y/120V
 - b. Line to Ground: 400 V for 208Y/120V.
 - c. Neutral to Ground: 400 V for 208Y/120V

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
 - a. Instantaneous trip.

- b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I^2t response.
4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 5. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (5-mA trip with 4-6 mA range).
 6. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 7. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
 8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
 - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1.
 1. Install panelboards in approximate locations indicated on Drawings.
 - a. Review final locations of panelboards in finished areas with Owner/Engineer prior to installation.
 - b. Coordinate final panelboard locations with other equipment and services to maintain NEC required work space and dedicated area.
- B. Mount top of trim 90 inches above finished floor unless otherwise indicated.
- C. 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.

- D. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Maximum of 6 FT to handle of top circuit breaker.
 - 2. Set field-adjustable, circuit-breaker trip ranges.
- E. Place spare circuit breakers in the OFF position.
- F. Install filler plates in unused spaces.
- G. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.
- H. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
- D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. 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 stated in NETA Acceptance Testing Specification. 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.
- 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. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

- A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges in the field as directed by the engineer.

END OF SECTION 262416

SECTION 262726

WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Refer to 260500 for General Electrical Requirements.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Receptacles, receptacles with integral GFCI, and associated device plates.
 - 2. Isolated-ground receptacles.
 - 3. Snap switches.
 - 4. Floor service outlets, poke-through assemblies, and service poles.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- D. RFI: Radio-frequency interference.
- E. TVSS: Transient voltage surge suppressor.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

- 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. Comply with NFPA 70.

1.6 COORDINATION

- A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
 - 1. Cord and Plug Sets: Match equipment requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
 - 1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
 - 2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
 - 3. Leviton Mfg. Company Inc. (Leviton).
 - 4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.2 STRAIGHT BLADE RECEPTACLES

- A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
 - a. Cooper; 5351 (single), 5352 (duplex).
 - b. Hubbell; HBL5351 (single), CR5352 (duplex).
 - c. Leviton; 5891 (single), 5352 (duplex).
 - d. Pass & Seymour; 5381 (single), 5352 (duplex).
- B. Hospital-Grade, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498 Supplement SD.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 8300 (duplex).
 - b. Hubbell; HBL8310 (single), HBL8300H (duplex).
 - c. Leviton; 8310 (single), 8300 (duplex).
 - d. Pass & Seymour; 9301-HG (single), 9300-HG (duplex).
- C. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; CR 5253IG.
(U of M Project No's. 1-266-09-1477)
(Design Development)

- b. Leviton; 5362-IG.
 - c. Pass & Seymour; IG6300.
 - 2. Description: Straight blade; equipment grounding contacts shall be connected only to the 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.
- D. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; TR8300.
 - b. Hubbell; HBL8300SG.
 - c. Leviton; 8300-SGG.
 - d. Pass & Seymour; 63H.
 - 2. Description: Labeled to comply with NFPA 70, "Health Care Facilities" Article, "Pediatric Locations" Section.

2.3 GFCI RECEPTACLES

- A. General Description: Straight blade, non-feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.
- B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; GF20.
 - b. Pass & Seymour; 2084.
- C. Isolated-Ground, Duplex Convenience Receptacles:
- 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; IG5362BLS.
 - b. Hubbell; IG5362SA.
 - c. Leviton; 5380-IG.
 - 2. Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

2.4 SNAP SWITCHES

- A. Comply with NEMA WD 1 and UL 20.
- B. Switches, 120/277 V, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way), 2224 (four way).
 - b. Hubbell; CS1221 (single pole), CS1222 (two pole), CS1223 (three way), CS1224 (four way).
 - c. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224-2 (four way).
 - d. Pass & Seymour; 20AC1 (single pole), 20AC2 (two pole), 20AC3 (three way), 20AC4 (four way).
- C. Pilot Light Switches, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221PL for 120 V and 277 V.
 - b. Hubbell; HPL1221PL for 120 V and 277 V.
 - c. Leviton; 1221-PLR for 120 V, 1221-7PLR for 277 V.
 - d. Pass & Seymour; PS20AC1-PLR for 120 V.
 - 2. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."
- D. Key-Operated Switches, 120/277 V, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221L.
 - b. Hubbell; HBL1221L.
 - c. Leviton; 1221-2L.
 - d. Pass & Seymour; PS20AC1-L.
 - 2. Description: Single pole, with factory-supplied key in lieu of switch handle.
- E. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 1995.
 - b. Hubbell; HBL1557.
 - c. Leviton; 1257.

- d. Pass & Seymour; 1251.
- F. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 1995L.
 - b. Hubbell; HBL1557L.
 - c. Leviton; 1257L.
 - d. Pass & Seymour; 1251L.

2.5 WALL PLATES

- A. Single and combination types to match corresponding wiring devices.
 - 1. Plate-Securing Screws: Metal with head color to match plate finish.
 - 2. Material for Finished Spaces: 0.035-inch- thick, satin-finished stainless steel
 - 3. Material for Unfinished Spaces: Galvanized steel

2.6 POKE-THROUGH ASSEMBLIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Hubbell Incorporated; Wiring Device-Kellems.
 - 2. Pass & Seymour/Legrand; Wiring Devices & Accessories.
 - 3. Square D/ Schneider Electric.
 - 4. Thomas & Betts Corporation.
 - 5. Wiremold Company (The).
- B. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.
 - 1. Service Outlet Assembly: Flush type with services indicated.
 - 2. Size: Selected to fit cored holes in floor and matched to floor thickness.
 - 3. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
 - 4. Closure Plug: Arranged to close unused cored openings and reestablish fire rating of floor.

2.7 FINISHES

- A. Color: Wiring device catalog numbers in Section Text do not designate device color.
 - 1. Wiring Devices Connected to Normal Power System Gray unless otherwise indicated or required by NFPA 70 or device listing.

2. Isolated-Ground Receptacles: As specified above, with orange triangle on face.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
- B. Coordination with Other Trades:
 1. Take steps to insure that devices and their boxes are protected. 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 the boxes.
 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
 1. Do not strip insulation from conductors until just 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 meet provisions of 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. Pigtailling existing conductors is permitted provided the outlet box is large enough.
- D. Device Installation:
 1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
 2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
 3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.

4. Connect devices to branch circuits using pigtails that are not less than **6 inches** in length.
 5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
 6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
 7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
 8. Tighten unused terminal screws on the device.
 9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
- E. Receptacle Orientation:
1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the left.
- F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
- G. 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.
- H. 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, multigang wall plates.
- I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

- A. Comply with Division 26 Section "Identification for Electrical Systems."
1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
1. Test Instruments: Use instruments that comply with UL 1436.
 2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

- B. Tests for Convenience 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 not acceptable.
 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. The 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.

END OF SECTION 262726

SECTION 265100 - INTERIOR LIGHTING

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. Refer to 260500 for General Electrical Requirements.

1.2 SUMMARY

- A. Section Includes:
 - 1. Interior lighting fixtures, lamps, and ballasts.
 - 2. Emergency lighting units.
 - 3. Exit signs.
 - 4. Lighting fixture supports.
- B. Related Sections:
 - 1. Division 26 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 DEFINITIONS & REFERENCES

- A. BF: Ballast factor.
- B. CCT: Correlated color temperature.
- C. CRI: Color-rendering index.
- D. LER: Luminaire efficacy rating.
- E. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting fixture, including ballast housing if provided.
- G. Latest Edition of Referenced Standards:
 - 1. American National Standards Institute (ANSI)
 - a. C78.379 - Electric Lamps - Incandescent and High-Intensity Discharge Reflector Lamps - Classification of Beam Patterns.
 - b. C82.1 - Ballasts for Fluorescent Lamps – Specifications.
 - c. C82.4 - Ballasts for High-Intensity Discharge and Low Pressure Sodium Lamps (Multiple Supply Type).
 - 2. National Fire Protection Association (NFPA)
 - a. 70 - National Electrical Code.

- b. 101 - Life Safety Code.
3. Underwriters Laboratory (UL)
 - a. 924 - Standard for Emergency Lighting and Power Equipment.

1.4 SUBMITTALS

- A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
 1. Physical description of lighting fixture including dimensions.
 2. UL nameplate data
 3. Emergency lighting units including battery and charger.
 4. Ballast, including BF.
 5. Energy-efficiency data.
 6. Air and Thermal Performance Data: For air-handling lighting fixtures. Furnish data required in "Submittals" Article in Division 23 Section "Diffusers, Registers, and Grilles."
 7. Sound Performance Data: For air-handling lighting fixtures. Indicate sound power level and sound transmission class in test reports certified according to standards specified in Division 23 Section "Diffusers, Registers, and Grilles."
 8. Life, output (lumens, CCT, and CRI), and energy-efficiency data for lamps.
 9. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.
 - a. Testing Agency Certified Data: For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by manufacturer.
 - b. Manufacturer Certified Data: Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. Shop Drawings: For nonstandard or custom lighting fixtures. Include plans, elevations, sections, details, and attachments to other work.
 1. Lighting Shop Drawings shall be in one submittal. Incomplete submittals will be returned without being reviewed.
 2. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Wiring Diagrams: For power, signal, and control wiring.
- C. Quantity Invoices:

1. The contractor shall submit quantity invoices for all lamps and ballasts which qualify for energy rebates.
- D. Installation instructions.
- E. 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. Lighting fixtures.
 2. Suspended ceiling components.
 3. Partitions and millwork that penetrate the ceiling or extends to within 12 inches of the plane of the luminaires.
 4. Ceiling-mounted projectors.
 5. Structural members to which suspension systems for lighting fixtures will be attached.
 6. Other items in finished ceiling including the following:
 - a. Air outlets and inlets.
 - b. Speakers.
 - c. Sprinklers.
 - d. Smoke and fire detectors.
 - e. Occupancy sensors.
 - f. Access panels.
 7. Perimeter moldings.
- F. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
- G. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.
- H. Field quality-control reports.
- I. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.
 1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.
- J. Warranty: Sample of special warranty.

1.5 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. Electrical Components, Devices, and Accessories:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. UL labeled, complete with lamps.
 3. UL listed for use indicated on Drawings (i.e., outdoor, wet location, explosion-proof, etc.).
- C. Comply with NFPA 70.
- D. FM Global Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

1.6 COORDINATION

- A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.7 WARRANTY

- A. 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 Fluorescent Ballast 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.

1.8 REGULATORY REQUIREMENTS

- A. Conform to requirements of NFPA 70 and NFPA 101.
- B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Products: Per Light Fixture Schedule

2.2 GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS

- A. Contractor provides all light fixtures complete with lamps, ballasts, accessories and mounting hardware required for complete installation as shown on the drawings or as specified by the Light Fixture Schedule.
- B. Contractor coordinates the fixture mounting accessories for all ceiling types. Contractor verifies ceiling finishes, grid system, clearances, and structure suspension system, before placing light fixture orders to insure correct application. Refer to architectural reflected ceiling plans, specifications and details for ceiling systems, installation and exact light fixture locations.

- C. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- D. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
 - 1. Fluorescent fixtures shall be designed and listed for through-wiring.
 - 2. Lamps, ballasts and specified accessories factory-installed
 - 3. Provide end cap adapters permitting direct connection between fixtures where continuous rows installation is indicated.
 - 4. Parabolic aluminum louvers designed for use with tri-phosphor lamps to eliminate or provide very low iridescence. Louvers free of dents, grip marks, and scratches.
 - 5. Compact fluorescent downlight cones designed for use with tri-phosphor lamps to eliminate or provide very low iridescence.
 - 6. Compact fluorescent downlights located in corridors shall be oriented with lamps perpendicular to the corridor.
- E. Metal Parts: Free of burrs and sharp corners and edges.
- F. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
- G. 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.
- H. Diffusers and Globes:
 - 1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - a. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
 - b. UV stabilized.
 - 2. Glass: Annealed crystal glass unless otherwise indicated.
- I. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located 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 and ballast characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter code (T-4, T-5, T-8, T-12, etc.), tube configuration (twin, quad, triple, etc.), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.
 - c. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.

- d. Start type (preheat, rapid start, instant start, etc.) for fluorescent and compact fluorescent luminaires.
- e. ANSI ballast type (M98, M57, etc.) for HID luminaires.
- f. CCT and CRI for all luminaires.

2.3 BALLASTS FOR LINEAR FLUORESCENT LAMPS

- A. General Requirements for Electronic Ballasts:
 1. Comply with UL 935 and with ANSI C82.11.
 2. Designed for type and quantity of lamps served.
 3. Ballasts shall be designed for full light output unless another BF, dimmer, or bi-level control is indicated.
 4. Sound Rating: Class A.
 5. Total Harmonic Distortion Rating: Less than 10 percent.
 6. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 7. Operating Frequency: 42 kHz or higher.
 8. Lamp Current Crest Factor: 1.7 or less.
 9. BF: 0.88 or higher.
 10. Power Factor: 0.98 or higher.
 11. Parallel Lamp Circuits: Multiple lamp ballasts shall comply with ANSI C82.11 and shall be connected to maintain full light output on surviving lamps if one or more lamps fail.
- B. Luminaries controlled by occupancy sensors shall have programmed-start ballasts.
- C. Electronic Programmed-Start Ballasts for T5 and T8 Lamps: Comply with ANSI C82.11 and the following:
 1. Lamp end-of-life detection and shutdown circuit for T5 diameter lamps.
 2. Automatic lamp starting after lamp replacement.
- D. Single Ballasts for Multiple Lighting Fixtures: Factory wired with ballast arrangements and bundled extension wiring to suit final installation conditions without modification or rewiring in the field.
- E. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.
 1. Dimming Range: 100 to 5 percent of rated lamp lumens.
 2. Ballast Input Watts: Can be reduced to 20 percent of normal.
 3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.
 4. Control: Coordinate wiring from ballast to control device to ensure that the ballast, controller, and connecting wiring are compatible.

2.4 BALLASTS FOR COMPACT FLUORESCENT LAMPS

- A. Description: Electronic-programmed rapid-start type, complying with UL 935 and with ANSIC 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:
1. Acceptable Manufacturers:
 - a. Roberts
 - b. Energy Savings, Inc.
 2. Lamp end-of-life detection and shutdown circuit.
 3. Automatic lamp starting after lamp replacement.
 4. Sound Rating: Class A.
 5. Total Harmonic Distortion Rating: Less than 20 percent.
 6. Transient Voltage Protection: IEEE C62.41.1 and IEEE C62.41.2, Category A or better.
 7. Operating Frequency: 20 kHz or higher.
 8. Lamp Current Crest Factor: 1.7 or less.
 9. BF: 0.95 or higher unless otherwise indicated.
 10. All compact fluorescent lamps (low wattage, triple, and biax) ballasts produced by a single manufacturer.
 11. Preheat start and has an integral cut off circuit automatically activated at lamp failure.
 12. Power Factor: [0.95] [0.98][, except fixtures designated as "Residential" may use low-power-factor electronic ballasts] or higher.
 13. Interference: Comply with 47 CFR 18, Ch. 1, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.

2.5 EMERGENCY FLUORESCENT POWER UNIT

- A. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with ballast. Comply with UL 924.
1. Emergency Connection: Operate one fluorescent lamp(s) continuously at an output of 1100 lumens each. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
 2. Nightlight Connection (As indicated on Drawings only): Operate one fluorescent lamp continuously.
 3. Test Push Button and Indicator Light: Visible and accessible without opening fixture or entering ceiling space.
 - a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.

- b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
4. Battery: Sealed, maintenance-free, nickel-cadmium type with minimum seven-year nominal life.
5. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
6. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.6 EXIT SIGNS

- A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
 1. Self-Powered Exit Signs (Battery Type): LED. Integral automatic charger in a self-contained power pack.
 - a. Battery: Sealed, maintenance-free, nickel-cadmium type.
 - b. Charger: Fully automatic, solid-state type with sealed transfer relay.
 - c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 - d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 - f. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.7 FLUORESCENT LAMPS

- A. T8 rapid-start lamps, rated 32 W maximum, nominal length of 48 inches, 2800 initial lumens (minimum), CRI 75 (minimum), color temperature 3500K, and average rated life 20,000 hours unless otherwise indicated.
- B. T5 rapid-start lamps, rated 28 W maximum, nominal length of 45.2 inches, 2900 initial lumens (minimum), CRI 85 (minimum), color temperature 3500K, and average rated life of 20,000 hours unless otherwise indicated.
- C. Standards
 1. ANSI C82.1

2.8 LIGHTING FIXTURE SUPPORT COMPONENTS

- 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 steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.
- E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage
- F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Sequencing
 - 1. Coordinate with other trades and with other electrical work.
 - 2. Delay installation of fixtures until completion of construction in each area as required to prevent damage and contamination of fixtures and diffusers.
 - 3. Do not remove protective wrapping on louvered fixtures until fixtures are ready for operation.
 - 4. Do not operate fixtures for construction lighting in lieu of temporary lighting except with approval of the construction manager.
- B. Lighting fixtures:
 - 1. Set level, plumb, and square with ceilings and walls unless otherwise indicated.
 - 2. Install lamps in each luminaire.
- C. Temporary Lighting: If it is necessary, and approved by Architect, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.
- D. Remote Mounting of Ballasts: Distance between the ballast and fixture shall not exceed that recommended by ballast manufacturer. Verify, with ballast manufacturers, maximum distance between ballast and luminaire.
 - 1. Install fixtures after building is enclosed, weathertight, and environmental conditions are nominally equivalent to the expected for completed spaces.

2. Install lighting fixtures, complete with lamps, at approximate locations shown and at heights indicated on Drawings.
 - a. Coordinate exact locations with other trades to avoid interferences and ensure accessibility for maintenance.
 - b. Install specified lamps in each luminaire.
 3. Operate each luminaire after installation and connection. Inspect for proper connection and operation.
- E. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.
1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each fixture. Locate not more than 6 inches from lighting fixture corners.
 2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
 3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
 4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.
- F. Suspended Lighting Fixture Support:
1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
 2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
 3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.
 4. Do not use grid as support for pendant luminaires. Connect support wires or rods to building structure.
- G. Air-Handling Lighting Fixtures: Install with dampers closed and ready for adjustment.
- H. Pole-mounted Fixtures
1. Install poles on concrete bases as indicated on drawings.
 - a. Provide templates, layout data, and material weights to General Contractor for his use in providing pole bases.
 - b. Supply data in sufficient manner to prevent delays.
 2. Anchor bolts by pole manufacturer:
 - c. Furnished with location template.
 - d. Obtain anchor bolts, hardware, and location templates for existing poles to be re-installed from original manufacturer.
- I. Cleaning and Relamping

1. Clean all fixtures and ensure that all lamps are new and operational at completion of construction and prior to acceptance of facility by Owner.
 2. Replace all components damaged during construction such as scratched lenses and diffusers.
- J. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.2 IDENTIFICATION

- A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

- A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.
- B. Verify that self-luminous exit signs are installed according to their listing and the requirements in NFPA 101.
- C. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.4 STARTUP SERVICE

- A. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner. Burn-in fluorescent and compact fluorescent lamps intended to be dimmed, for at least 100 hours at full voltage.

3.5 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.
1. Adjust aimable luminaires in the presence of Architect.

END OF SECTION 265100

SECTION 28 31 11

DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

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. Notification appliances.
 - 2. Magnetic door holders.
 - 3. Remote annunciator.
 - 4. Addressable interface device.
 - 5. Digital alarm communicator transmitter.

1.3 DEFINITIONS

- A. LED: Light-emitting diode.
- B. NICET: National Institute for Certification in Engineering Technologies.

1.4 SYSTEM DESCRIPTION

- A. Noncoded, UL-Certified addressable system, with multiplexed signal transmission, dedicated to fire-alarm service only. Main panel is provided under separate contract. This contract is responsible for connections and devices shown on the Drawings.

1.5 SUBMITTALS

- A. General Submittal Requirements:
 - 1. Submittals shall be approved by authorities having jurisdiction.
 - 2. Shop Drawings shall be prepared by persons with the following qualifications:
 - a. Trained and certified by manufacturer in fire-alarm system design.
 - b. NICET-certified fire-alarm technician, Level III minimum.
- B. Product Data: For each type of product indicated.
- C. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
 - 2. Include voltage drop calculations for notification appliance circuits.
 - 3. Include battery-size calculations.
 - 4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.

5. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.
- D. Qualification Data: For qualified Installer.
- E. Field quality-control reports.
- F. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "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 "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:
 - a. Frequency of testing of installed components.
 - b. Frequency of inspection of installed components.
 - c. Requirements and recommendations related to results of maintenance.
 - d. 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.
 7. Copy of NFPA 25.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
- B. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system
- 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.

1.7 PROJECT CONDITIONS

- A. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:
 1. Notify Owner no fewer than seven days in advance of proposed interruption of fire-alarm service. Comply with University shutdown procedures.

1.8 SEQUENCING AND SCHEDULING

- A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide fire alarm system by one of the following:
1. NOTIFIER; a Honeywell company.
 2. SimplexGrinnell LP; a Tyco International company.
 3. Prior approved equal

2.2 SYSTEMS OPERATIONAL DESCRIPTION

- A. Fire-alarm signal initiation shall be by one or more of the following devices:
1. Smoke detectors.
 2. Beam detectors.
 3. Heat detectors.
 4. Flow switch activation.
- B. Fire-alarm signal shall initiate the following actions:
1. Continuously operate alarm notification appliances.
 2. Identify alarm at fire-alarm control unit and remote annunciators.
 3. Transmit an alarm signal to the remote alarm receiving station.
 4. Release fire and smoke doors held open by magnetic door holders.
 5. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode. Interface to existing air handling units.
 6. Close smoke dampers in air ducts of designated air-conditioning duct systems. Interface to existing smoke dampers in existing air handling unit duct work.
 7. Recall elevators to primary or alternate recall floors. Interface to existing elevator recall system.
 8. Record events in the system memory.
- C. Supervisory signal initiation shall be by one or more of the following devices and actions:
1. Duct smoke detector activation.
 2. Valve supervisory switch.
- D. System trouble signal initiation shall be by one or more of the following devices and actions:
1. Open circuits, shorts, and grounds in designated circuits.
 2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
 3. Loss of primary power at fire-alarm control unit.
 4. Ground or a single break in fire-alarm control unit internal circuits.
 5. Abnormal ac voltage at fire-alarm control unit.
 6. Break in standby battery circuitry.
 7. Failure of battery charging.
 8. Abnormal position of any switch at fire-alarm control unit or annunciator.
- E. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators.

2.3 SYSTEM SMOKE DETECTORS

- A. General Requirements for System Smoke Detectors:
 - 1. Comply with UL 268; operating at 24-V dc, nominal.
 - 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
 - 3. 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.
 - 4. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 - 5. Integral Visual-Indicating Light: LED type indicating detector has operated.
- B. Beam Detectors: Reflected beam some detectors. Consists of both transceivers and reflectors.
- 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.
 - 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. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.4 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.
- B. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.
- C. Visible and Audible/Visual Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- high letters on the lens.
 - 1. Rated Light Output:
 - a. 15/30/75/110 cd, selectable in the field.
 - 2. Mounting: Ceiling-mounted unless otherwise 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, red.

2.5 MAGNETIC DOOR HOLDERS

- A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.
 1. Electromagnet: Requires no more than 3 W to develop 25-lbf holding force.
 2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
 3. Rating: 24-V dc.
- B. Material and Finish: Match door hardware.

2.6 ADDRESSABLE INTERFACE DEVICE

- A. Description: Microelectronic monitor module, UL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.
- B. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

- A. Comply with NFPA 72 for installation of fire-alarm equipment.
- B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.
 1. Connect new equipment to new control panel provided under separate contract.
- C. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.
- D. Fire-Alarm Control Unit: Surface mounted, with tops of cabinets not more than 72 inches above the finished floor.
- E. Annunciator: Install with top of panel not more than 72 inches above the finished floor.

3.2 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 Division 08 Section "Door Hardware." Connect hardware and devices to fire-alarm system.
 1. Verify that hardware and devices are UL listed for use with fire-alarm system in this Section 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. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
 1. Existing smoke dampers in air ducts of designated air-conditioning duct systems.
 2. Alarm-initiating connection to elevator recall system and components.
 3. Supervisory connections at valve supervisory switches.
 4. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.

3.3 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
- B. Install framed instructions in a location visible from fire-alarm control unit.

3.4 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.

3.5 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by authorities having jurisdiction
- B. Perform tests and inspections.
- C. 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 NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
 - b. Comply with "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 "Test Methods" Table in the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
 - 3. 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.
- D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
- E. Fire-alarm system will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.
- G. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.
- H. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

END OF SECTION 28 31 11